Altered motor control, posture and the Pilates method of exercise prescription

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Certificate of authorship/originality

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Abstract

Aims

- To determine whether a basic set of Pilates exercises improves the efficiency of load transfer through the pelvis
- To compare the effects on chronic, mild low back pain (LBP) symptoms of three slightly different Pilates based regimes

Methods

A between subjects equivalent group experimental design was used

  - Independent variable: type of exercise training (three groups)
  - Dependent variables: efficient load transfer through the pelvis as measured by the stork test in weight bearing; low back pain symptoms

At entry, to establish baseline values, subjects completed an Oswestry Disability Questionnaire and recorded the frequency, intensity and duration of their back pain in an average week. Also, a Stork test was recorded.

Thirty-nine volunteers with mild chronic low back pain (CLBP) were taught four Pilates based exercises before being randomly allocated to one of three groups for the addition of other interventions.

- Groups A received four basic exercises
- Groups B and C received an additional relaxation posture using a specific spinal support
- Group C received an additional postural training exercise

Exercises were performed three times per week for six weeks and recording was done once per week for eight weeks. For each of the eight weeks, subjects recorded frequency, intensity and duration of back pain

At the final assessment, subjects completed another Oswestry Disability Questionnaire, returned their recording sheets, had a stork test recorded and their exercises checked.

Results

Oswestry Disability Questionnaire

Pre and post comparison of answers showed only one statistically significant improvement among subject groups. This was for question one, '*Do you have back pain at present?*' where Group B reported significantly less pain post program compared with pre program (Wilcoxon, z=-2.496, p=0.013).

Number of days of pain

Group B experienced a statistically significant reduction in the number of days of pain between Week 1 and Weeks 6 to 8 ($F_{7,84}$=6.4, p=0.0001). Post hoc analysis using Scheffé showed significant differences between Week 1 and Weeks 6, 7 and 8 and between Week 2 and Week 8 ($p<0.05$). There were statistically significant differences by week within Group C ($F_{7,77}$=3.29, p=0.0041), but they only show up with Fisher ($p<0.05$) and they were between Week 1 and Weeks 6, 7 and 8, Week 2 and Weeks 6, 7 and 8, Week 3 and Weeks 6 and 7 and between Week 4 and Week 7.

Some of the improvements were lost once exercising ceased at the end of week 6

Duration of back pain episodes

All groups experienced a reduction in the mean length of the shortest, longest and average pain episodes. At week eight all groups had subjects who were pain free (Group A: 7.7%, Group B: 30.8%, Group C: 25%) and in Group B, no subjects reported pain episodes longer than six hours. However, differences were not statistically significant for the duration of this study.

Some of the improvements were lost once exercising ceased at the end of week 6

Intensity of pain across all lengths of pain episodes

While, all groups experienced a reduction in the intensity of pain across all lengths of pain episodes, the only statistically significant inter group difference involved Group A and Group B on the shortest pain episodes at Week 6, with Group B experiencing a greater reduction in pain intensity than Group A (Kruskal Wallis, $p=0.02$)

And for all groups, intensity of pain tended to rise once exercising ceased

Stork test in weight bearing

These results were inconclusive and this could have been because total subject numbers were small. As the same person carried out all tests, it was unlikely to reflect changes in measurement method or interpretation. However, it did raise questions regarding the stance for commencement of the test and this led to an investigation to assess the importance of the stance to the test results.

Procedure

A physiotherapist, experienced in taking Stork tests, who was not aware of the purpose of the test, carried out the stork tests. Ten subjects stood in three different standing positions to commence the test and neither subjects nor standing positions were tested consecutively.

- Not one subject had the same result recorded from all three positions
- There was no pattern to the results observed
- Two subjects had different results recorded from all three positions

Observations

- For correct execution of the exercises:
  - Subjects required follow up supervision
  - Those who had more individual attention learnt faster than those who had less
  - Understanding the intent of the exercise was more important than other factors such as age

- During periods of nonpractice correct execution was quickly forgotten

- Good acceptance of the program - 95% of the subjects decided to continue
  - However, compliance became an issue – the fewer the LBP symptoms, the less likely the subjects were to comply

Conclusions

Current pain symptoms (Oswestry Disability Questionnaire) showed a reduction in pain and all groups experienced statistically significant reductions in the frequency, duration and intensity of pain across the weeks of exercising. However, effects were not statistically significant between the groups, except for one instance.

Results indicate that other factors such as postural training and relaxation may impact on exercise programs and as the psoas muscle was the intended target for relaxation and training, it may indicate its importance in exercise rehabilitation.

Consistency of practice, supervision and follow up are important for correct exercise execution and once exercising ceases, reductions in LBP symptoms tend to diminish.

Stork test results and subsequent examination suggested that further investigation of the testing process was necessary and a further study was designed.

Aim of the stork test study

- To examine whether changing the stance of the starting position for the stork test on the weight-bearing leg altered the test outcome.

Methods

Seventy-four healthy, mobile adult volunteers took part. The exclusion criteria were stroke, spinal fusion, significant scoliosis, antalgic gait, hip or knee replacement or significant leg length difference. Subjects could suffer from minor ailments, including low back pain.

It was a within subjects experimental design with the independent variables being the four different stances for the commencement of the test and the dependent variable being the stork test which was measured using thumb locations on the posterior superior iliac spine and the second sacral spinous process.

All 296 tests were videoed and subsequently reviewed on a computer screen using a horizontal grid to identify the vertical direction and relative distance of thumb movement.

Results

Consistency between stance pairs was at best fair, with Kappa values ranging from $\kappa = -0.03$ to $\kappa = 0.34$. In conclusion, the starting stance influenced the outcome of the stork test with more than 64% of subjects failing to have consistent results across all four stances.

Discussion

For a comparable stork test measurement pre and post treatment, the same starting stance should be used. In addition the study showed that:

- The thumb on the innominate could rise, lower or remain at the same level
- The thumb on the sacrum could rise, lower or remain at the same level
- These movements could be independent

Thus, it is important to take note of the relative movement between the innominate (os coxa or pelvic bone) and sacral thumb positions since these can move independently during the test.

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Contents

Publications to date

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Chapter I: Introduction and aims

Background

Most people will experience back pain at some point in their adult lives. For example, Papageorgiou et al (1995) carried out a one-year study of two family medical practices in South Manchester, United Kingdom, and found that 35% of the male patients and 42% of the female patients consulted these practices for low back pain with a prevalence of one month.

Most back pain will resolve over a period of six to eight weeks without intervention, however, some people will continue to suffer back pain, which will then be categorised as chronic after three months. A small proportion of the time, this pain will be explained by medical imaging and will involve conditions such as herniated discs, facet joint osteoarthritis and stenosis. The majority of the time, the pain will be categorised as mechanical low back pain (LBP), that is, pain that is not explained by anatomical changes on a medical image. Federspiel et al (1989) looked at 8,000 cases of back injury workers compensation claims in Tennessee for 1986 and found that more than 90% were mechanical (non-specific) in nature.

Even when pain symptoms can be traced to anatomical disorders, there are huge variations in pain level and disability between symptomatic individuals, so that often, the degree of pain cannot be explained by the scan. For example, an individual with a mild disc derangement without nerve root compression may experience little or no pain, while another individual with a similar scan may be quite incapacitated and experience high levels of pain.

Treatment

The individualisation of symptoms and the non-specific nature of mechanical low back pain have made treatment difficult. Surgery is expensive, both financially and in days lost to work during recovery and rehabilitation for the patient and carer and is not an option unless there are clear anatomical disorders that will respond to surgery. Even after surgery, individuals may continue to suffer pain symptoms.

Response to treatment is as individualised as symptoms. Some individuals obtain relief with manual therapies such as physiotherapy, osteopathy, chiropractic and massage, while others use exercise programs and interventions such as acupuncture. Non-steroidal antiinflammatories and analgesics may be used to control symptoms and ‘back care’ programs are used to provide information, advice and reduce anxiety. However there is no clear advantage to using one intervention over another and interventions may be combined or used sequentially. Currently, keeping active and trying to maintain as normal a lifestyle as possible is the advice that underpins all interventions. The Victorian Workcover Authority in its publication *Guidelines for the management of employees with compensable low back pain: A summary for medical practitioners* (1996) recommends returning to normal activity and an active exercise program.

Impact

Among the chronic LBP (CLBP) sufferers are many that have recurring bouts of pain or constant low-grade pain (mild CLBP) that either does not necessitate days away from work or only the occasional day from work and are not included in many of the back pain statistics because they do not seek compensation. Only a third of CLBP conditions are work related (Australian Bureau of Statistics 2001), however, in the 2001 National Health Survey by the Australian Bureau of Statistics, 20.8% of Australians (a rise from 4.9% in 1995) reported back pain lasting six months or longer (Australian Bureau of Statistics 2002) and 24% said that in the two weeks prior to the survey, they had their ‘role in life’ affected by LBP (Australian Bureau of Statistics 2002) and in 2004, it was the third most commonly reported long term health condition in people aged 25-64 years (Australian Institute of Health and Welfare 2008).

Mild CLBP sufferers feel a level of discomfort that leads them to avoid certain practices such as sitting for long periods and standing for long periods and this may impinge on their lifestyle by causing them to make choices about travel and activities in relation to their CLBP symptoms. These individuals may take over-the-counter medication for pain, may or may not have sought a medical opinion and may seek treatment in a number of different areas and try different therapies. Waddell noted (1996) that 40% of LBP patients in the

United States see chiropractors for their back pain. Although separate statistics are not available for CLBP, chiropractic is used for the treatment of musculoskeletal conditions, and in Australia in 2001, chiropractors were the second most commonly consulted allied health professional (after chemists) in the two weeks prior to the National Health Survey (Australian Bureau of Statistics 2002). In 2004, chiropractors had dropped to third on the list, having been overtaken by physiotherapists (Australian Bureau of Statistics 2006), however both figures had increased from 2001 levels.

Costs

The economic burden of CLBP has risen considerably over the years. Even without considering indirect costs such as wages lost, Frymoyer and Cats-Baril (1991) found that total direct costs in the United States, which included physicians' fees, hospital services and drugs almost doubled, rising from 12,922,740,000 USD in 1984 to 24,336,153,000 USD in 1990, only six years later. In Australia in 2000-01, chronic low back pain (CLBP) accounted for 12.2% or $567,000,000 of the direct health care expenditure for arthritis and musculoskeletal conditions. Of that, some 40% was on hospital services, 15% on pharmaceuticals, 15% on out of hospital medical service and 20% on other professional services. Expenditure on allied health professional services accounted for more than $145,000,000 of this expenditure and pharmaceuticals, prescription and over-the-counter, accounted for more than $75,000,000 (Australian Institute of Health and Welfare 2006).

Exercise interventions

Exercise has become an attractive therapy for the treatment of CLBP over the last 15 years because it is a cheaper alternative to manual therapies and has other associated health benefits, such as helping to reduce heart disease and obesity, as well as imparting a feeling of well being. In a society, where a third of the population is sedentary (Australian Bureau of Statistics 2006), an intervention that encourages activity and personal responsibility and that can be as costly or inexpensive as required by the participant is viewed as desirable.

There are many different types of exercise interventions that may be undertaken in many different ways. They include supervised group exercise, such as gym classes and aqua aerobics; individual exercise that may also be taken in a group, such as swimming, bush walking and bicycle riding; and structured exercise programs that involve a high degree of concentration on correct execution, such as yoga, motor control exercises and Pilates.

Motor control

Motor control involves the brain's 'feed-forward' mechanism. This refers to the brains ability to activate specific muscles involved in joint stabilisation in anticipation of movement. Appropriate activation provides a more stable base for movement to take place and a better distribution of forces generated by that movement. A delay in this mechanism has been associated with LBP (Hodges et al 1996, 1997-a, 1997-b). Exercises that involve a co-contraction of transversus abdominis and multifidus prior to movement have been developed to retrain this function (Richardson et al 2003, 2004). There are similarities in these exercises with Pilates. Pilates also involves a hollowing of the abdominal wall and some Pilates exercises developed by Eve Gentry that utilise a 'neutral spine' position and focus on static trunk stabilisation are included in motor control programs.

Stork test

This is a palpation test developed by Hungerford (Hungerford et al 1998, 2003, 2004) to determine whether the 'feed-forward' mechanism involved in motor control is working appropriately when weight is transferred from two feet to one foot. The test detects anterior/posterior rotation of the innominate (os coxa or pelvic bone).

In standing, it is possible for the sacrum to nutate or counternutate. Nutation, which means 'forwards nodding' and counternutation, which means 'backward nodding' are the terms commonly applied to the head and sacral movement. However in the case of the sacrum, it refers to the base of the triangle, which is positioned superiorly. The biomechanical modelling of Snijders et al (1993) demonstrated that nutation of the sacrum with posterior rotation of the innominate places the sacroiliac joint (SIJ) in a 'self-braced' or locked position that is less vulnerable to the shear forces of vertical loading (i.e. that is better able to distribute forces through the pelvis) than is counternutation of the sacrum with anterior rotation of the innominate. In the 'self-braced' position, the combined action of transverse muscle fibres, such as gluteus maximus) would compress the SIJ and facilitate the transmission of forces across the joint. Hungerford et al (2003) showed that the onset of gluteus maximus contraction was delayed in symptomatic individuals.   This finding was supported by Richardson and colleagues (2002) who showed that specific activation of the transversus abdominis muscle led to a reduction in SIJ laxity.

Pilates

Pilates has had an enormous impact on the exercise industry. Its focus on trunk stabilisation, dynamically through controlled trunk movement as well as statically when the trunk is kept still while the limbs move, has gained it a reputation for being an appropriate exercise intervention for CLBP. Physiotherapists commonly recommend Pilates as an adjunct to therapy or as an appropriate continuing exercise intervention. However, Pilates, in its focus on developing energy efficient movement patterns also directs its attention to 'good posture' and 'over recruitment' in muscle activation. The Pilates principles of centring, concentration, control, precision, flow of movement and breath is vital to correct execution of the exercises. It is important to note that the relaxation of appropriate muscles that activate too soon or inappropriately in a movement is as crucial to correct execution as the activation component.

However, evidence for the efficacy of Pilates is largely anecdotal. This study is an attempt to begin examination of the non-strengthening components of Pilates and their impact on the outcome of a preparatory Pilates strengthening program that uses three exercises involving dynamic stabilisation and one exercise involving static stabilisation.

Aims

When this research project was planned, it was intended to address the following:

> to determine whether a basic set of Pilates exercises would improve the efficiency of load transfer through the pelvis, as measured by the stork test;
>
> to compare the effects of three slightly different Pilates programs on LBP symptoms;
>
> evaluate the addition of a specific relaxation technique and a postural retraining exercise to a basic set of four Pilates exercises in relation to LBP symptoms.

However, findings from repeated stork tests, the primary tool for determining efficient load transfer through the pelvis, raised questions that suggested the accepted application of the stork test needed further research and clarification. Given the relevance of this to the interpretation of the present research and other related reports that use the stork test to assess functional stability, a second study was designed. This study has been presented as a separate chapter that includes in its entirety, aims, methods, results and discussion.

Format of thesis

Chapter II: Literature review

This review identifies and evaluates published research that (i) illustrated the protocols involved in exercise based studies or (ii) were of particular relevance to the proposed research. There was no research available on the impact of relaxation on exercise outcomes.

Chapter III: Methods

This chapter describes the experimental design and procedures. The instruments that were used are presented in appendices I to XIV. Note that a second chapter was also required and it is presented in chapter VI.

Chapter IV: Results

The first section covers the Oswestry Disability Questionnaire. The second section covers low back pain symptoms. The third section covers the stork test. The findings from the stork test were the impetus for undertaking the second study.

Chapter V: Discussion

Chapter VI: The stork test on the weight bearing leg as applied to four different stances for the commencement of the test.

This chapter includes aims, methods, results and discussion for the additional study.

References

Appendices

This includes all written information provided to subjects.

Publications to date

Chapter II: Literature review

Introduction

The intention of this review was to identify and evaluate published research that (i) illustrated the protocols involved in exercise based studies or (ii) were of particular relevance to the proposed research.

The literature was located by extensive online search of the following databases, 1991 to 2006: MEDLINE, Meditext, PubMed, ProQuest and EBSCO. Primary keywords were exercise, low back pain, chronic low back pain and Pilates. Fifteen were selected because they represented a cross section of the different types of studies currently published.

Problems with exercise based studies

Generally, the problems with exercise-based studies are the number of subjects, compliance and the length of time over which the study is run. Recruiting large numbers of subjects for exercise studies is not easy because exercise involves time, effort and sustainability of commitment. Monitoring over the long term can be difficult and often relies on subjects returning questionnaires, whereas, in the short term, it is difficult to recruit enough subjects to reach statistical power. If the intervention is short term with a long term follow up, care must be taken to investigate subjects' other activities and interventions in the intervening period, otherwise, it is not possible to evaluate whether effects are due to the original exercise program, another program and/or intervention.

Klaber Moffet et al (1999) used an hour's program of strengthening and aerobic exercises, stretching and relaxation in eight sessions over four weeks (intervention: N = 89; control: N = 98) with a follow up at 12 months. At six weeks, Klaber Moffett and colleagues found significant differences in pain reduction within the intervention group ($p = 0.03$), but only marginal differences between the groups (intervention: N = 85; control: N = 94). At 12 months followup, Moffett et al (1999) reported a significant improvement in the disability questionnaire score ($p = 0.03$) and the Aberdeen back pain scale ($p = 0.01$). However, it is not known whether the intervention group continued an exercise program or made lifestyle changes that contributed to the effect.

Problems with comparison

There are many variables in exercise programs and the administration of those programs that make comparisons between studies difficult. These include program focus, supervision, length of session, intensity of exercise, number of exercise repetitions, frequency of exercise, number of subjects and period over which the program was run. Also, it is difficult to match subjects with controls because subjects' normal activity and pain levels are variable. For example, Hides et al (1994) noted multifidus muscle atrophy in the presence of injury at the level of injury. However, Danneels et al (2000), using computed tomography (CT), only found atrophy at L4 after matching activity levels in low back pain (LBP) subjects and controls prior to the CT.

Exercise programs may be general, such as an aerobic program, which will also increase overall muscle tone and the production of endorphins; or more specific, having been directed at an identified difference in function between pain subjects and healthy controls. Hodges and Richardson (1996, 1997a, 1997b) showed that the activation of transversus abdominis was delayed prior to movement of the upper and lower limbs in subjects with LBP compared to controls and Hides et al (1995) and Richardson et al (2004) developed a specific exercise technique involving the use of real-time ultrasound for biofeedback to address this motor control delay. Also, O'Sullivan et al (2004) showed that some chronic low back pain (CLBP) subjects had motor control impairments that led them to adopt postural preferences and movements that were in the direction of their pain and that retraining the motor control system through retraining posture and movement reduced that pain (O'Sullivan 2004).

Even strength-based exercise programs may be general or specific. The program may encompass 'whole-body' strengthening exercises for the trunk and the limbs or may focus specifically on trunk extensors and flexors because these have been identified as being weaker in CLBP subjects compared to controls (Suzuki, Endo 1983). Specific impairments may be treated by direction specific exercises, such as the McKenzie back extension exercises commonly used by physiotherapists to treat lumbar disc protrusions, or they may follow the subjects' direction preference for exercise (Long et al 2004).

Some exercise protocols are linked as in the spinal stabilisation exercises that specifically strengthen muscles involved in segmental stabilisation, such as multifidus and transversus abdominis that are also involved in motor control delay. Richardson et al (2003, 2004) developed a series of specific exercises to address these issues. Other muscles, such as psoas (Dangaria and Naesh 1998), may also suffer atrophy and exercises may be specifically designed to build strength in those muscles.

Problems with comparison of exercise intervention to no intervention

It is difficult to compare exercise intervention to no intervention in treatment for chronic low back pain because exercise increases muscle tone and strength and decreases fatigability. These are positive factors that bring many benefits in terms of well being that impact on general health and people's perceptions. Range of movement is sometimes measured, but this does not necessarily relate to pain, although it may relate to function. Symptom reduction, specifically pain and changes in function are the usual outcomes to be measured, although fear-avoidance beliefs, catastrophisation, other psychological factors and coping strategies may be measured also. Visual analogue scores, where pain is measured on a line, and semantic differential scores, where pain is measured as a number between one and ten, are the usual measures of pain. The comparison of functional questionnaires completed pre and post program and/or days away from work are used to measure changes in function.

It is not surprising, given the positive physiological effects of exercise, that in studies, which compare an exercise intervention to controls with no intervention, results usually favour exercise. Gundewall et al (1993) and Suni et al (2004) used similar intervention periods of 13 months and 12 months respectively.

However, the exercise programs that were used were quite different. Gundewall et al (1993) used a functional trunk muscle-strengthening program of 20 minutes six times per month over 13 months that was undertaken and supervised in the work environment (intervention: N = 28; control: N = 32). Suni et al (1993) used ten specifically designed exercises to improve motor control, trunk stabilisation, hip joint flexibility and thoracic rotational mobility, twice per week over 12 months with one session supervised and the other not (intervention: N = 52; control: N = 54).

Gundewall et al (1993) reported significantly fewer days off work ($p < 0.0004$) and Suni et al (2004) found a significant reduction in intensity of pain using a visual analogue scale for the last seven days (at 12 months) compared to baseline with a geometric mean ratio of experimental group to control group of 0.61 (95%CI 0.30 to 0.97). Interestingly, Suni and colleagues (2004) did not find statistically significant differences between groups with the Oswestry Disability Questionnaire and the Pain and Disability Index. In any case, although both programs produced some favourable results, it is not possible to determine whether it was due to the physiological exercise effects as opposed to the specific exercises as controls did not receive exercise.

Identification of sub-sets in CLBP

Given the many different approaches, large numbers of exercises used in some studies and the identification of CLBP sub-sets in patients, the current focus is on trying to determine which exercises are better for whom. O'Sullivan et al (1997), looked at a very specific group of 44 subjects suffering from a spondylolisthesis or spondylolysis. Using a motor control program of co-contraction of transversus abdominis and lumbar multifidus once per week over ten weeks, O'Sullivan et al found significant differences between the specific exercise group (N = 22) and the control group (N = 22) at ten weeks with a pain intensity decrease ($F_{1,20} = 75.5$, $p < 0.0001$) and a functional disability level decrease ($F_{1,20} = 35.8$, $p < 0.0001$). At a 30 months follow up, O'Sullivan and colleagues also found that significant differences had been maintained however, there was no reporting of exercise habits or other interventions in the intervening period.

O'Sullivan et al's study is important because it was one of the initial studies that generated a new focus in exercise prescription – namely motor control – the muscle recruitment patterning in rehabilitation exercise. Although the study identified a sub-set of CLBP patients and demonstrated positive outcomes for the experimental group, the interpretation of the findings remains tentative. This relates to the nature of the control group where individual subjects completed different kinds and amounts of exercise at the direction of their general practitioners. Certainly the experimental group showed significant improvement over the control group but whether the causal factor was the muscle firing sequence or the supervised structured exercise program per se cannot be determined.

Adequacy of experimental variables

Many of the studies suffer from a lack of control of the variables and in home exercise studies compliance also becomes a significant factor. Frost et al (1998) compared eight sessions of a supervised fitness program plus a home exercise program plus a back care program (N = 29) to controls that only received the home exercise and back care program (N = 31). They reported significant within group and between group differences in disability scores after two years. There was a mean reduction in the intervention group of 7.7% on the Oswestry Low Back Pain Disability Index score ($p < 0.001$) compared to 2.4% in controls ($p > 0.05$) and there was a statistically significant difference between the groups ($p < 0.04$). However, the interpretation of these results is questionable because the compliance levels among the home exercise group were not investigated and follow up of the experimental group did not include investigation about their continued use of a supervised fitness program. In addition, it cannot be determined whether fitness training, the supervision, or the combination was the important factor.

Mannion et al (1999) compared physiotherapy that included exercises, both strength and isometric, administered twice weekly in half hour individual sessions over three months with the addition of home exercises (N = 46) to muscle reconditioning, using equipment, administered for one hour per week over three months in groups of two or three (N = 44) to an aerobic program containing strength and relaxation exercises, administered for one hour over three months to groups of 12 subjects (N = 47). Mannion et al found no significant within group or between group differences, either after treatment or one year after treatment, although all subjects improved significantly pre to post treatment (greatest pain, $r = 0.47$, $p = 0.0001$; average pain, $r = 0.48$, $p = 0.0001$). All programs contained exercises and Mannion et al concluded that the inexpensive nature of the aerobic program made it more desirable than the others in deciding which form of exercise to recommend.

Descarreaux et al (2002) looked at home exercise only and compared two different kinds of home exercise programs. Twenty subjects were randomised into two groups after being matched for similar physical characteristics. The experimental group (N = 10) received exercises that were individualised in reference to the physical assessment. They received force and extensibility exercises which varied in intensity, quantity and type in relation to the assessed deficit. The control group (N = 10) received standard back care force and extensibility exercises and stretches. Exercises were all performed once per day and subjects kept a compliance diary. The experimental group received an exercise upgrade at three weeks. At six weeks, both groups showed improvement in muscle force and extensibility, but only the experimental group showed significant improvement on the Modified Oswestry Disability Questionnaire ($p = 0.028$) and pain levels ($p = 0.028$). A between groups comparison was not reported. The interpretation of these results is tentative also, because the control group did not receive an upgrade at three weeks. As well as advancement in difficulty, intrinsic to an upgrade is supervision and instruction to ensure correct execution of the exercises, which the control group did not receive. Therefore it is difficult to determine which was the important factor, the exercises or the supervision.

The better the study design, the less likely the differences between exercise programs. Koumantakis et al (2005) in a very carefully designed study compared trunk muscle stabilisation exercises involving the co-contraction of transversus abdominis and multifidus plus general exercise ($N = 29$) with general exercise ($N = 26$). All subjects received similar supervision and shared some exercises. The experimental group did not receive the classic trunk flexion and spine extension exercises, but received stabilisation exercises based on activating transversus abdominis and multifidus and postural training exercises based on a neutral spine position. Both groups received supervised exercise twice per week for eight weeks. Because stabilisation exercises generate less force, total exercise time was increased for the stabilisation group in an effort to balance total force output. In addition, both groups were asked to perform the exercises at home three times per week for a maximum of 30 minutes. At eight weeks, both groups had improved, but there were no significant differences between the groups then or at the 20 week follow up.

Studies involving direction specific exercises for CLBP

In regard to direction specific programs, Petersen et al (2002) and Miller et al (2005) looked at McKenzie treatment involving manual therapy, direction specific exercises and posture correction in comparison to a strength training program and a stabilisation program (respectively). Both studies involved a home program as well as supervised sessions, but precise detail about implementation of the McKenzie program is lacking, as this was prescribed individually. Whereas, Long et al (2004), in a well constructed study, looked at the specific directional exercise involved in a McKenzie program, after identifying a sub-set of subjects who were deemed suitable for such a program.

Petersen and colleagues (2002) compared intense strength sessions (N = 86) of six participants for 60 to 90 minutes twice per week to McKenzie treatment (N = 94) administered individually for a half hour at the discretion of the physical therapist. The strength program involved a warm up of low resistance and aerobic exercise followed by four strengthening exercises that began with 50 repetitions and increased to 100 over eight weeks. For both groups, there was a maximum of 15 sessions over eight weeks and then subjects were asked to continue with a home exercise program for two months. Both groups improved, however results showed no statistical difference between the groups and Petersen et al concluded that both treatments were equally effective.

Miller et al (2005) compared McKenzie exercise treatment (N = 14) to trunk muscle stabilisation exercises involving the co-contraction of transversus abdominis and multifidus (N = 15) in a program involving five weekly supervised sessions and a home program of 10 to 15 minutes (frequency unspecified). At six weeks, both groups showed improved scores. The stabilisation group had improved significantly in pain descriptor scores and the present pain index ($p = 0.01$, $p = 0.002$), whereas, the McKenzie group had only significantly improved in the present pain index ($p = 0.05$). However, there were no significant differences between the groups and there was no follow up.

Whereas, Long et al (2004) focused on identifying a sub-set of CLBP sufferers with a direction preference for exercise that brought an immediate reduction in pain and only those with a direction preference were recruited. They were randomly assigned to one of three groups (i) exercises that matched the direction preference (N = 70) (ii) exercises that were in a direction opposite to the preference (N = 62) (iii) multidirectional exercises (N = 69). All subjects had a minimum of three and a maximum of six visits over two weeks and were expected to do a home program several times daily. All groups improved and there were statistically significant differences between the directional preference group and the other two groups (who were not different to each other) on back pain intensity ($p < 0.001$) and interference with activity ($p = 0.014$), but not on disability. There was no follow up and it is not known whether pain improvements were maintained once exercising ceased.

However, Long and colleagues' (2004), O'Sullivan (2004) and O'Sullivan and colleagues' (1997) studies are important because they indicate that the identification of specific subgroups amongst CLBP sufferers may be more important for appropriate exercise prescription and produce better results than trying to find an exercise panacea that suits all.

Studies involving Pilates for CLBP

There are now a number of published studies using the Pilates method of exercise prescription, but only four involving CLBP. One was published in 2004 and the other three were published in 2006, after this present study was begun. Hadjipetrova and Dimitrova (2004) compared two groups who both received lumbar stabilisation exercises for one month. The control group continued with those exercises on a daily basis for two months and the experimental group stopped the stabilisation exercises and continued with Pilates mat exercises (Stott program), three times per week, for two months. Rydeard et al (2006) compared specific stabilisation exercises and hip extension exercises that were targeted at improving the gluteus maximus recruitment pattern (N = 21) to a control group that continued with their usual pattern of care (N = 18). Donzelli et al (2006) compared a ‘Mat4me’ Pilates ‘CovaTech’ program that included information (N = 22) to a back school program that included exercises (N = 21). Gladwell et al (2006) compared a Pilates program (N = 20) to controls (N = 14). Hadjipetrova and Dimitrova (2004), Rydeard et al (2006) and Donzelli et al (2006) also included follow-ups.

Unfortunately, Hadjipetrova and Dimitrova (2004) did not report pain results at three months. At the follow up (six months), 47% of the control group were still experiencing low back pain compared to 20% of the experimental group. However, no results were included to support this. Although, Hadjipetrova and Dimitrova compared exercise to exercise, the exercises were not specified and it is not known whether the groups continued with their exercises between the end of the intervention and the follow up.

Rydeard and colleagues (2006) tried to allow for the positive health benefits of exercise by only including subjects who already undertook a minimum of a half hour of moderate intensity exercise three times per week. Also, they tried to target a specific sub-set of subjects who demonstrated a delay in the onset of gluteus maximus activation in hip extension and scored a grade four or less on a five point graded strength scale for gluteus maximus.

The exercise program began with static stabilisation and specific hip extension exercises on a mat that were advanced to using special Pilates equipment (Universal Reformer – a sliding platform that is spring loaded and attached to a foot/hand bar) over four weeks. There was some individualisation in the program as subjects able to cope with dynamic stabilisation were then given more advanced exercises. Subjects undertook the program three times per week for one hour and there was a 15-minute home program to be undertaken six days per week.

There were significant between group differences with the experimental group improving significantly in average pain intensity ($p = 0.023$) and disability ($p = 0.002$) post treatment. Disability scores in the experimental group continued downwards between post treatment and the three months follow up and were maintained for another three months, but had begun to rise at the 12 month follow up. However, because the control group was unsupervised and the Pilates program increased the exercise intensity levels, it is difficult to tell whether supervision, intensity, specificity of the exercises, the Pilates program per se or a combination was the important factor.

Donzelli and colleagues (2006) did not specify the exercises in the programs, except to say that both programs included postural and respiratory education and stretching exercises. The back school program included trunk strengthening and extension exercises and the Pilates program included basic 'CovaTech' exercises that did not require any equipment. Both groups received ten one hour sessions on a daily basis and then subjects received a booklet so they could continue their exercises at home. Evaluations at one, three and six months showed no statistical between group differences in pain and disability. Both groups improved, with the greatest improvement being between pre-treatment and one month.

Gladwell and colleagues (2006) specified the Pilates exercises they used in six weekly one-hour supervised sessions plus two half-hour unsupervised home sessions. However, the control group received no intervention and again, it is not possible to determine whether the exercises or the supervision was the important factor in statistically significant results. Interestingly, although the Pilates group showed significant within group improvements on the Roland Morris Visual Analogue Score pre to post treatment ($p < 0.05$), the control group showed significant within group improvements in the Oswestry Disability Questionnaire pre to post treatment ($p < 0.05$). The only significant between group differences were in the pain diary for the change pre to post treatment with the intervention group showing significant improvements ($p < 0.05$).

Chapter III: Methods

Study design

The study was a between subjects equivalent group experiment with the independent variable being the type of exercise training (three groups) and the dependent variables being efficient load transfer as measured by the stork test (one-legged standing test) in weight bearing (Hungerford et al 2004) and low back pain (LBP) symptoms.

Ethics approval was obtained from the Human Research Ethics Committee (HREC) University of Technology Sydney (ethics documentation available if required) and screening and instruction were conducted at the University of Technology Sydney (UTS) between 1st July 2006 and 30th September 2007.

Stork test

The test was taken on the weight-bearing leg for the lift of the other leg. For the test on the right leg, the tester rested the thumb of the right hand on the posterior superior iliac spine (PSIS) and the rest of the hand on the right innominate. The left thumb was placed on the second sacral spinous process (S2). The subject was instructed to lift the left leg. For the test on the left leg, the tester rested the thumb of the left hand on the left PSIS and the thumb of the right hand on S2 and the subject lifted the right leg.

Advertising for volunteers

Fliers were distributed in the Ultimo area and advertisements were posted on the electronic staff notice board at UTS. An osteopath listed the project on his practice website and referred some of his patients to the project.

The advertising asked for subjects with 'sore, tired or aching backs' (chronic, mild low back pain) who were mobile, able to 'get up and down' from the floor and have time to do a forty minute home exercise program three times per week. It was explained that the program was not suitable for those with a clinical history of back pain or a clinically diagnosed back pathology. The HREC also added previous back surgery to the exclusion criteria and a requirement that all volunteers obtain a clearance from their medical practitioners that they were suitable for an exercise program. Those who replied to the initial advertisement then received a letter (Appendix I) outlining the time commitment and explaining that the information collected would be rendered anonymous and treated and stored according to the HREC guidelines and that subjects could withdraw at any time.

Initial screening

The initial screening was done individually. Subjects filled out a basic health history (Appendix II) and were asked for details of their current symptoms and the diagnosis and treatment of their LBP. Those who had previous back surgery or received a diagnosis of herniated discs, spondylolisthesis or stenosis were excluded and those who appeared to have disc or stenosis related symptoms were excluded also.

Subjects were asked whether they had a current exercise regime (Appendix III), what was included in the regime and how many times per week it was performed. Subjects were asked to maintain this regime and use the study exercise program in addition.

Subjects were asked how many times in the average week they suffered back pain and to record the length of the shortest, longest and average pain episodes. Using a ten point semantic differential scale to establish base line values, they were then asked to rate the severity of their back pain on each of the length of pain episodes.(Appendix III)

Subjects filled out a modified Oswestry Disability Questionnaire (Victorian Workcover Authority, 2004) (Appendix IV). The questionnaire was modified because the responses were more appropriate for a less mobile population than the subjects involved in this study. Each question had six answers that ranged from no pain or disability to total inability to perform the task. The final answer of 'total inability to perform the task' was replaced with a slightly less disabling response for some questions.

A postural assessment was performed, various bony landmark relationships were noted and a stork test in weight bearing recorded. (Appendix V)

Subjects signed a consent form (Appendix VI) that included the information that had been contained in the original letter of explanation as well as the HREC contact details and reference number and subjects retained a copy. They were then asked to return the following week to learn the exercises.

Exercises

Subjects were taught four basic exercises (Appendix VII) individually or in small groups of two to four subjects, before selecting a coloured token from a bucket, which randomly allocated a subject to a specific intervention group (A, B or C). The exercises were chosen because they were basic preparatory Pilates exercises. Three of the exercises focussed on thoracic spine mobility, as opposed to lumbar spine mobility and the fourth exercise focused on static trunk stability while moving the limbs.

Group A received only the four basic exercises while Groups B and C received a relaxation posture on a specifically designed spinal support to use before the basic exercises. The support was made from closed cell foam and was adjusted for the height and weight of the subject. (Appendix VIII). Group C also received a postural training exercise (Appendix IX) in sitting. The purpose was to help subjects find and maintain a neutral spine position through movement.

Subjects received written instructions with photographs for each exercise (Appendices VII, VIII, IX) and received a Frequently Asked Question Sheet (Appendix X) that was expanded after each exercise check when new questions were asked. Exercise checks were voluntary, however, subjects were asked to come in on the second and fourth weeks.

Each exercise in the basic program was performed with 40 repetitions and the postural training exercise was performed with 20 repetitions. Exercises were performed at home three times per week for six weeks.

Subjects were asked to pick three days each week they would do their exercises and a different day for recording. Recording and exercising were separated so that any immediate positive physiological effects would not influence responses.

Recording

For eight weeks, subjects were asked to record the number of days they experienced back pain in the previous week and whether they had participated in any activities that usually preceded low back pain. Using a 10-point semantic differential scale, subjects were asked to record the intensity and duration of the previous week's pain for the shortest, longest and average pain episodes. The recording sheets consisted of one page for each week with the majority of responses only requiring a circle and with room for a comment at the bottom (Appendix XI).

Final assessment

After eight weeks, subjects received a final assessment (Appendix XII) where they filled out another Oswestry Disability Questionnaire and were asked whether they had changed their normal exercise routine or received other interventions for LBP. As there were two weeks of not doing the exercise program, subjects had their exercises checked to see if they could remember how to execute them correctly. Subjects received a second postural assessment and a second stork test was recorded. Table 3.1 shows an age and gender distribution for subjects and Figure 3.1 shows subject flow through the study.

Age range	Men	Women
<30	3	5
30-39	2	4
40-49	2	5
50-60	6	9
>60	1	3
all subjects	14	26

Table 3.1 Age and gender distribution for the subjects who completed the final assessment

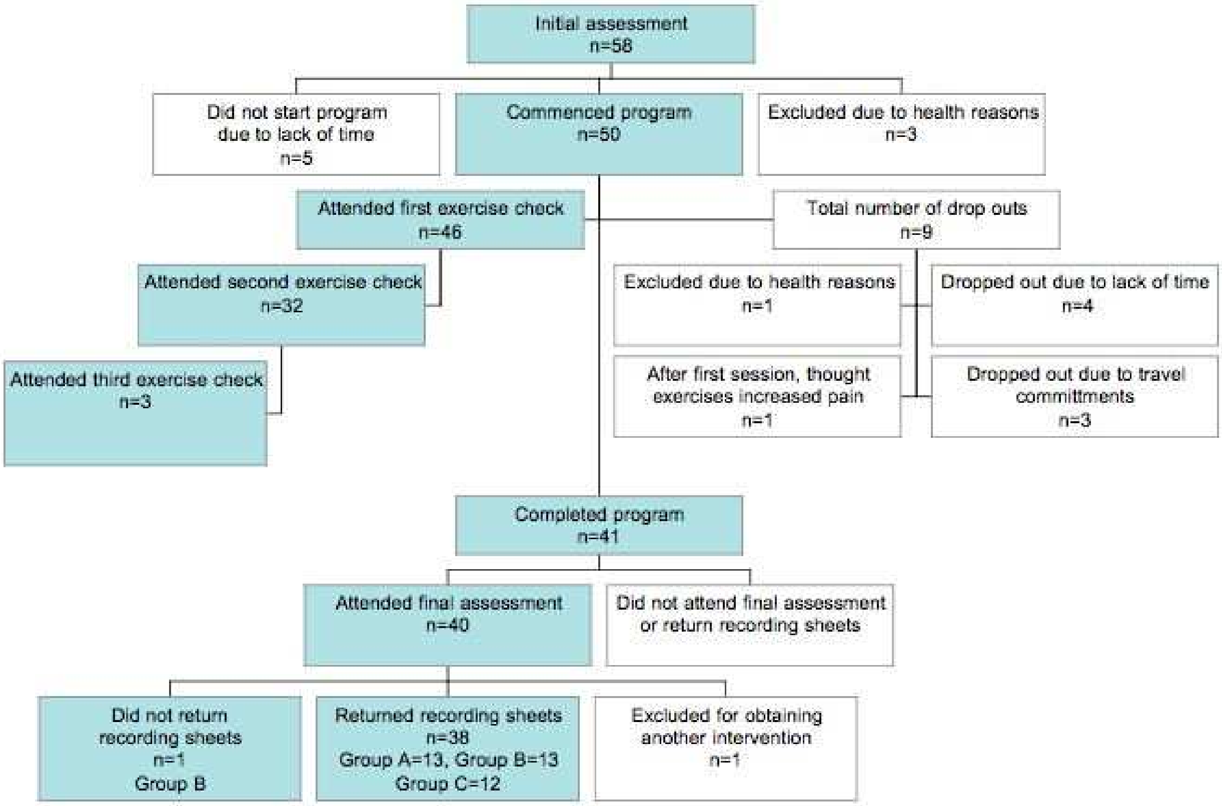

Figure 3.1: Subject flow through study

Initial stork test collection

A comparison of the stork test process pre and post program raised questions about the stance for the commencement of the test. It was decided to investigate further. A physiotherapist who was experienced in taking stork tests was engaged to perform tests on 10 subjects. Subjects were instructed to stand in three different positions for the commencement of the test. Neither subjects nor standing positions were tested consecutively and the physiotherapist was unaware that the subjects would commence the test from different stance positions.

Not one subject had the same result recorded from all three positions and there was no pattern to the results observed. Given the relevance of this to the interpretation of the present research, and the importance of the stork test as an assessment of functional stability, it was decided to design a second study with an increased number of subjects. A further application was lodged with the HREC. This study has been presented as a separate chapter that includes in its entirety, aims, methods, results and discussion.

Statistical tests

Standard descriptive statistics were used as appropriate. Inferential statistical analyses were used that were appropriate to the type of comparison involved. For ordinal level variables, Wilcoxon and Kruskal Wallis were used, depending on whether the groups were independent or correlated (repeated measures). For cardinal level variables, analysis of variance was used, with Scheffé or Fisher post hocs. In all tests alpha was set at $p = 0.05$. For statistical purposes, pain was divided into pain lasting less than one hour, pain lasting between one and six hours and pain lasting more than six hours.

Chapter IV: Results

Age and gender

There were no correlations for gender or age.

Oswestry Disability Questionnaire

Pre and post comparison of answers showed only one statistically significant improvement among subject groups. This was for question one, '*Do you have back pain at present?*' where Group B reported significantly less pain post program compared with pre program (Wilcoxon, $z = -2.496$, $p = 0.013$). (Figure 4.1)

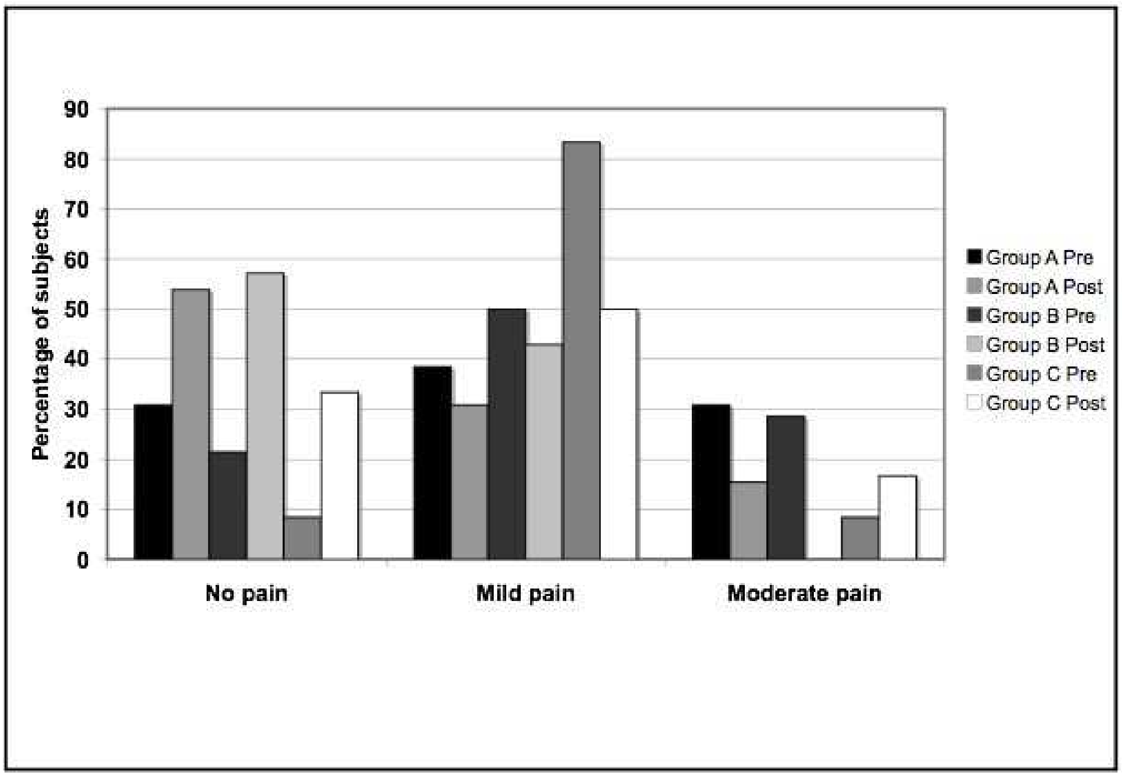

Figure 4.1: Oswestry Disability Questionnaire – question 1 – pre and post program

Number of days of pain

Group B experienced a statistically significant reduction in the number of days of pain between Week 1 and Weeks 6 to 8 ($F_{7,84} = 6.4$, $p = 0.0001$). Post hoc analysis using Scheffé showed significant differences between Week 1 and Weeks 6, 7 and 8 and between Week 2 and Week 8 ($p < 0.05$). There were statistically significant differences by week within Group C ($F_{7,77} = 3.29$, $p = 0.0041$), but they only show up with Fisher ($p < 0.05$) and they were between Week 1 and Weeks 6, 7 and 8, Week 2 and Weeks 6, 7 and 8, Week 3 and Weeks 6 and 7 and between Week 4 and Week 7. (Figure 4.2)

Some of the improvements were lost once exercising ceased at the end of week 6.

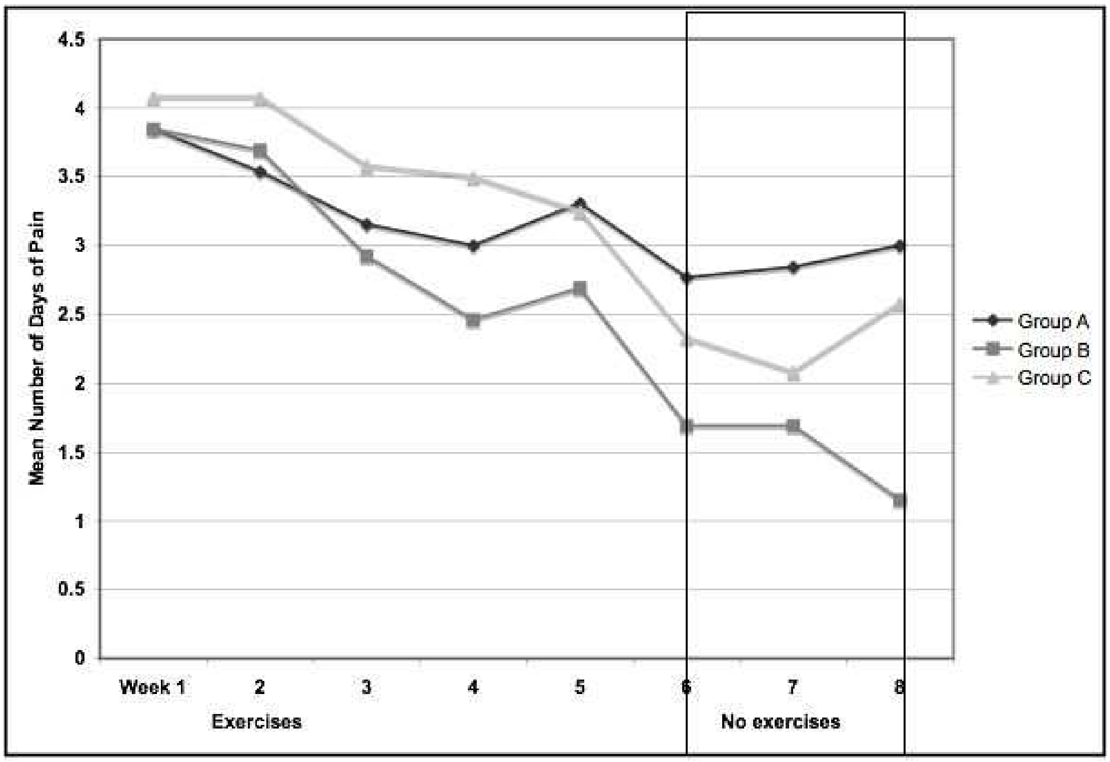

Figure 4.2: Number of days of pain each week

Duration of back pain episodes

All groups experienced a reduction in the mean length of the short, long and average pain episodes and at Week 8 all groups included some subjects who were pain free. While the proportions of pain free subjects in Groups B and C (30.8% and 25% respectively) were higher than for Group A (7.7%), differences were not statistically significant.

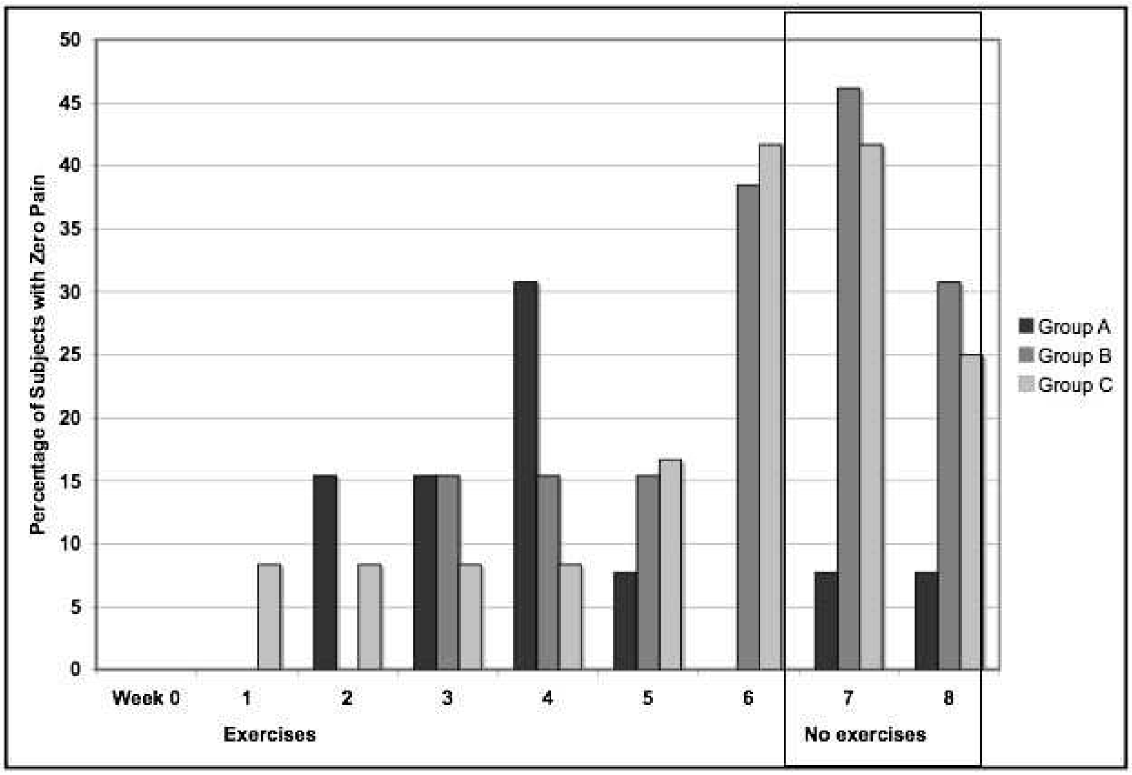

Figure 4.3: Duration of pain on the average length of pain episodes

Intensity of pain across all lengths of pain episodes

All groups experienced a reduction in the intensity of pain across all lengths of pain episodes. However, Group A failed to experience a further reduction in intensity of pain after week four, while Groups B and C continued to experience a further reduction in pain through to week six. (Figure 4.4)

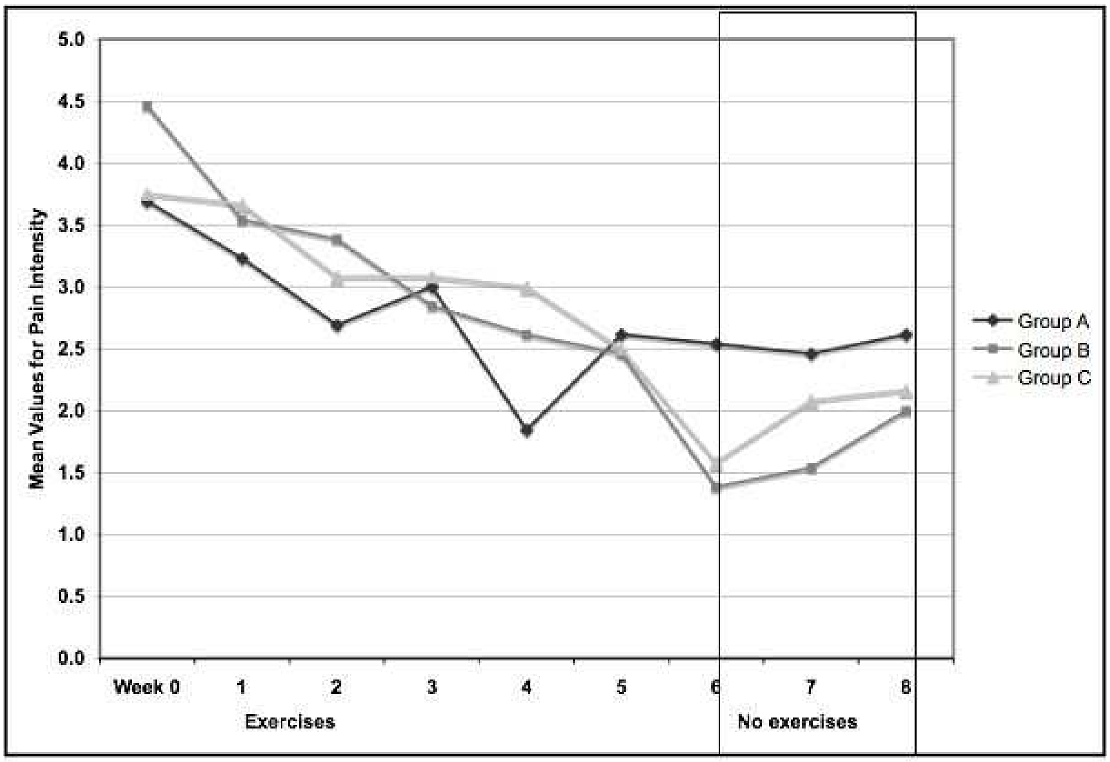

Figure 4.4: Intensity of pain on the average duration of pain episodes

The only statistically significant inter group difference involved Group A and Group B on the shortest pain episodes at Week 6, with Group B experiencing a greater reduction in pain intensity than Group A (Kruskal Wallis, p = 0.02) For all groups, intensity of pain tended to rise once exercising ceased. (Figure 4.5)

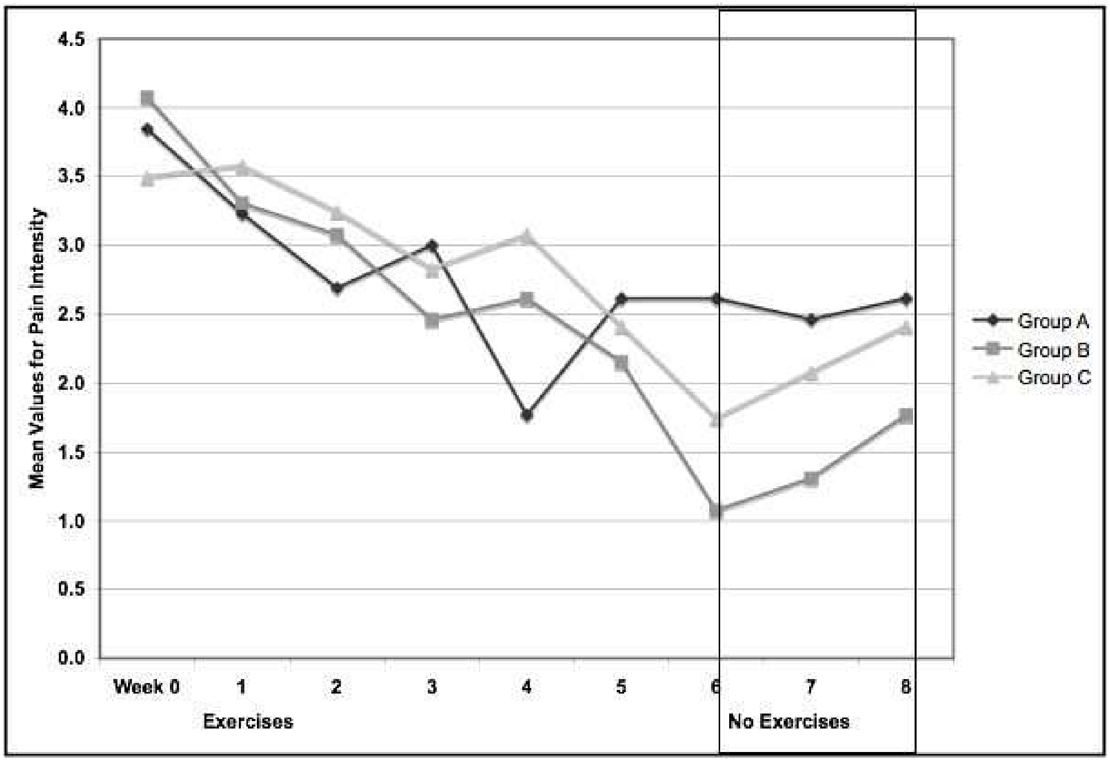

Figure 4.5: Intensity of pain on the short length of pain episodes

Stork test in weight bearing

These results were inconclusive and this could have been because total subject numbers were small. As the same person carried out all tests, it was unlikely to reflect changes in measurement method or interpretation. However, it did raise questions regarding the stance for commencement of the test and this led to an investigation to assess the importance of the stance to the test results.

Procedure

A physiotherapist, experienced in taking stork tests, who was not aware of the purpose of the test, carried out the stork tests. Ten subjects were given three different standing positions for the commencement of the stork test

- normal stance
- feet close together
- feet shoulder width apart

Neither subjects nor standing positions were tested consecutively.

Results

Not one subject had the same result recorded from all three positions and there was no pattern to the results observed. Furthermore, two subjects had a different result recorded in each of the three positions, indicating further investigation would be useful.

Chapter V: Discussion and Conclusions

Observations

The health benefits of exercise are well documented and as many studies, including the reviewed studies (Gundewall 1993, Klaber Moffet et al 1999, Suni et al 2004), demonstrate the positive effects of exercise over no exercise in symptom reduction, it was decided that all groups would receive exercise. Only four exercises were used, in order to avoid the difficulties subjects might have in trying to execute a large number of exercises correctly. However, because of the large number of repetitions, the intensity of the program would still be high and the frequency of exercising could be reduced. As compliance might be a problem (Long et al 2004, Descarreaux et al 2002, Miller et al 2005), it was thought that three sessions per week would be more likely to elicit compliance than a daily session. The range of movement was modest, so that the exercises would be in a safe movement range for all subjects without clinical pathologies, particularly as this was a home program.

The importance of supervision in an exercise program became evident in this study. Despite the initial training session and detailed instructions and photographs (Appendix VII, VIII, IX), subjects in this study required follow up supervision to ensure correct execution of the exercises and during periods of non-practice correct execution was quickly forgotten. At the first exercise check in Week 2, all subjects needed correction, but at the second check in Week 4, most demonstrated proficiency. However, at the final assessment, after two weeks of not doing exercises, fewer than half the subjects performed the exercises correctly.

This necessity of supervision is supported by the literature review where studies showed that those groups who received supervision in their exercise programs experienced symptom improvement. In Petersen and colleagues' study (2002), where an effort was made to equalize the contact time and supervision between the two groups, both groups improved and there were no statistical differences between the groups. It suggests that correct execution of even basic exercises is difficult for most people. We are habitual in our movement preferences and it is only through supervision we are made aware of these movement habits.

Because the recruitment of subjects was staggered, some subjects received their instruction individually, rather than small groups, and it was noted that those who had more individual attention learnt correct execution faster than those who had less. However, understanding the intent of the exercise was more important for correct execution than other factors such as age.

Although there were a large number of repetitions that were time consuming and eventually became boring, the program was well received, as evidenced by the 95% of subjects that continued on with the project, after having completed the original program.

No studies were found that looked at the effect of relaxation on exercise outcomes for chronic low back pain (CLBP) sufferers, however, the loss of ability for CLBP sufferers to find and maintain a neutral spine has been well documented (Panjabi 1992, O'Sullivan et al 2003, O'Sulivan 2004) and the establishment of a neutral spine position is fundamental to many exercise programs, including motor control and modern day Pilates programs.

Oswestry Disability Questionnaire

The questionnaire (Victorian Workcover Authority, 2004) (Appendix IV) was modified to suit the population in this study, who were more mobile and with less severe CLBP than those for which the original questionnaire was intended. Apart from the first question that asked whether the subject was in pain at that moment, the other nine questions related to a range of common activities that covered personal care, lifting, walking, sitting, standing, sleeping, socialising, travelling and homemaking. Each question had six answers that ranged from (1) no pain or disability to (6) pain causing complete disability. The final answer of 'total inability to perform the task' was replaced with one indicating slightly less disability. Distance walked was changed to time spent walking so that it was consistent with the other time answers. The time comment of 'not longer than one hour' was increased to two hours and 'not longer than ten minutes' was increased to fifteen minutes. However, this proved unnecessary as subject responses were confined to the first three answers and the majority to the first two.

Further, when subjects returned for the final assessment, frequent comments were that although they had not attempted the activity at the level in question, they thought they would experience pain if they did so and thus ticked that response. For example, those who had ticked 'pain prevents me walking more than two hours non-stop' had not tried to walk the two hours non-stop prior to the final assessment and thought they would have pain if they did so.

This problem was addressed by inclusion of a different question. As the recruiting of subjects spanned 18 months, an eleventh question was included for half the cohort (Appendix XIII). This asked subjects to list a frequently performed activity that caused pain; for example, tying up shoes or carrying groceries. This question appeared useful because it was specifically tailored to the individual and referred to an activity that could not be avoided in daily life. By the final assessment, subjects had often forgotten what task they had listed as the activity. When presented with that task, it was more likely to elicit a different response because their pain focus had moved to another activity. However, the data was not analysed because subject numbers were too small.

The Oswestry Disability Questionnaire was chosen because it appeared the most suitable questionnaire to modify. However, as data was entered, it became apparent that the standard scoring technique was not appropriate, because at the initial assessment some subjects' point scores were too low to detect an appreciable downward change at the final assessment. It was decided to check each question separately.

Completion of program

Only data from subjects who completed the program were used, because it was the results of the intervention that were of interest. Most of those who dropped out did so for lack of time and did not provide any data other than at the initial assessment. One subject had recourse to another intervention during the study period and that data were not used.

Exercises

The rationale behind the abdominal exercises, the relaxation posture and the postural training exercise was a re-education of the psoas muscle. Anecdotally, a dysfunctional psoas has been identified as being one of the muscle culprits contributing to LBP.

The aim in the abdominal exercises was to have abdominal muscle activation with minimal assistance from the psoas muscle. To achieve this, the movement range needed to be limited (Andersson et al 1995, 1997). The exercises needed to be executed with the legs straight, as per the preparation for some Pilates exercises, because electromyographic evidence (Andersson et al 1995, 1997) shows that when the knees are flexed, psoas is activated. Even with the legs supported over a cushion, psoas is still activated and so if subjects experienced low back discomfort with their legs straight resting on the floor, then they were instructed to place a cushion or books under their feet, to elevate the legs slightly, while keeping them straight. (Figures 5.1 and 5.2)

In addition, to ensure correct execution and movement response, subjects were generally not instructed to ‘hollow abdominally, but to draw the ‘hip bones’ (anterior superior iliac spines) together and not have the stomach ‘let go’, ‘bulge’ or protrude during the exercise. If subjects found this difficult, they were instructed to activate the pelvic floor. A gentle hollowing was only used if all else failed to elicit the correct movement response.

Figure 5.1: Exercise 1 – the abdominal curl

Figure 5.2: Exercise 4 – the oblique abdominal curl

The side lying exercise focused on static trunk stability in the frontal plane. A neutral spine was maintained during an isometric contraction of the lateral flexor muscles while raising both legs just off the floor.

Figure 5.3: Exercise 2 – the side lying double leg lift

The spine extension exercise focused on thoracic extension while maintaining lumbar control, although some lumbar extension would occur. The degree of extension was individual. Subjects were instructed to keep to the comfortable range.

Figure 5.4: Exercise 3 – the spine extension

For the relaxation posture, subjects were instructed to lie supine with the head raised on a cushion or pillow. The foam support was placed under the lumbar spine, the knees were flexed and the legs placed over the seat of a chair. Subjects were instructed to stay in that posture till they felt relaxed, but no longer than five minutes. Although psoas muscle activity would occur in this position (Andersson et al 1995), activity does not preclude a relaxation effect for muscles experiencing increased tone. Some therapists also use gentle, rhythmic movement to produce a relaxation effect. It was thought that relaxation might improve muscle recruitment patterns by delaying the onset of over active muscle fibres.

The postural retraining exercise, similar to a Pilates exercise called ‘Genie’, was the most difficult exercise to teach and the exercise most often poorly executed. Subjects were instructed to sit erect on a stool with their ‘natural’ spinal curves (neutral spine). They were then instructed to lean back and return erect while maintaining this neutral spine position. The purpose of the exercise was to help subjects find and maintain a neutral spine position through movement and specifically load the psoas muscle. The psoas muscle is more active in erect sitting than slumped sitting (Andersson et al 1994, Juker et al 1998) and leaning back involves the psoas muscle in eccentric muscle contraction (Gibbons et al 2002). The subtleties of the exercise, even though understood, were difficult to communicate experientially. This may explain why Group B, who only had the relaxation posture, had consistently lower scores than Group C, who had the relaxation posture and the postural training exercise.

Figure 5.5 Postural training

All subjects were asked to keep all exercises within a pain free range, even though the range of movement for all exercises was small. For some subjects, movement was minimal and for others, more moderate.

Frequently asked questions

As noted above, follow-up supervision to ensure correct execution is vital to provide benefit in terms of improved posture, muscle tone and a reduction in LBP. At the first exercise check it became evident that even though subjects had received written instructions and photographs, they needed more assistance and a frequently asked questions sheet (FAQ) was begun (Appendix X). As subjects were seen either individually or in small groups of two or three, this sheet was constantly updated as the project continued. The sheet contained information on different approaches to thinking about the execution of the exercises. Which approach achieved the desired effect was quite individual.

Protocols for exercise observance

One unforseen problem was that subjects might not exercise if they felt unwell. As the first few subjects returned for their final assessments, it became clear that not all subjects had completed six weeks of exercise. For example, one subject had influenza and had only completed four weeks of exercises, but had still kept recording. This may have influenced results.

This problem was solved by the inclusion of a protocol sheet (Appendix XIV). It was explained that subjects should undertake six weeks of exercises and that if a week was missed it needed to be added on. Therefore, it was possible for a subject to take seven weeks to complete the six-week program. However, if the occasional session was missed it could be ignored, although subjects were asked to record this. However, subjects became more diligent in their exercise habits after the production of the protocol sheet. Subjects were instructed to photocopy a blank recording page and record for the missed week. However, the data for the missed week of sessions was not used.

Twenty-three subjects returned for their final assessment at two weeks post completion of exercises. Twelve subjects, due to other commitments or taking longer to complete the six weeks of exercise, returned at three weeks. However, two returned at four weeks post exercise and one subject at nine weeks. The reasons for delay were hospitalisation, moving house and marking papers.

Cessation of exercise

In the reviewed studies (O’Sullivan et al 1997, Frost et al 1998, Klaber Moffet et al 1999, Mannion et al 1999, Hadjipetrova and Dimitrova 2004, Rydeard et al 2006, Donzelli et al 2006) where there was follow-up of subjects, there was no reporting of exercise habits between the post-test period and follow-up. It was thus decided to see if cessation of exercise would affect results. Thus, subjects were asked to cease the home program for two weeks, but continue recording. Results showed that LBP symptoms increased once exercising stopped.

At the final assessment, subjects commented that having established an exercise routine, they wanted to continue exercising. It was decided to apply for an amendment to the ethics application (ethics documentation available if required) so that subjects could continue on the study, but change groups. For example, if the subject was in Group A, the subject moved to Group B. However, although 95% of the subjects continued, compliance became an issue. Anecdotally, subjects mentioned diminished back pain as the reason for forgetting to exercise and/or record results. Recording sheets were either not returned or returned incomplete with apologies and there was not enough data for analysis. Interestingly, many of those who had used the foam support and then been transferred to Group A, where the foam support was not used, said that the execution of the exercises did not feel as comfortable as when the support had been used prior to exercising.

Measurements

Initial assessment

The initial assessment looked at a number of asymmetries usually treated by hands on techniques used by physiotherapists, osteopaths, chiropractors and musculo-skeletal physicians but no statistically significant changes were recorded in these pre to post treatment (Appendices V, XII).

Even for healthy subjects, practice and training improve abilities. Khalkhali et al (2004) showed that even proprioception, measured by sacral nutation, in healthy subjects could be improved with training. Therefore, improvements in mobility, flexibility and/or strength were not measured because they would be expected outcomes from an exercise program and may not relate to pain symptoms. For this reason and that, as previously mentioned, exercising per se has positive side effects, it was decided to compare exercise with exercise and use the stork test and LBP symptoms as a measure of efficacy.

The same exercises were used for each group because the effects of relaxation and postural training on the exercise outcome could not be determined if the exercises and intensity of exercise varied between groups.

Stork test

The stork test was used because although the exercises were not directed specifically at training sacral nutation, they did involve training the compression of some transverse fibres during thoracic flexion/extension and trunk stabilisation and this might lead to improved sacral nutation when transferring weight from two feet to one foot in standing.

Low back pain symptoms

Although subjects were asked how many times in the previous week they suffered back pain, this was often not completed. However, the question that asked on which days subjects experienced back pain was completed and this was used for frequency. Hence, pain on Wednesday, Friday and Saturday was recorded as a frequency of three for that week.

The question on activities that preceded back pain had poor completion rates or was misunderstood and the data was not used.

The three questions using semantic differential scales that involved circling responses and related to shortest, longest and average back pain and intensity of pain on those incidents were completed consistently and provided all the low back pain symptom data.

Pain perceptions change with focus and blocking out pain during daily activity is common. A number of subjects later commented that they did not realise how often or how much pain they had till they had to monitor their pain levels regularly. Baseline measurements were recorded at the initial assessment, however it might have been preferable to ask subjects to monitor their pain levels for a week prior to commencing the program and then used these recordings for baseline measurements.

Conclusions

All groups experienced a reduction in the mean number of days of pain, duration and intensity of pain each week. These effects were statistically significant within the groups across the weeks of exercising, but not between groups for the duration of this study. Subtle differences in efficacy between the three programs may not have been statistically significantly identifiable as sample sizes were small and length of exercise time was short (six weeks).

However, the importance of establishing effective, appropriate gentle exercise intervention for decreasing risk in an older population suffering poor balance, decreased mobility and strength leading to subsequent injury cannot be overstated. The health costs of musculoskeletal injury and disability are considerable (Australian Institute of Health and Welfare 2006)

Since Groups B and C experienced a greater reduction in symptoms than Group A, this may indicate that other factors such as relaxation and postural training impact on exercise programs. As the psoas muscle was the intended target for relaxation and training, it may also indicate its importance in exercise rehabilitation.

Reductions in LBP symptoms tended to diminish once exercising ceased, which raised questions about subjects' post intervention activities in other exercise studies that involved follow-up. It could be that one important value of a specific exercise program delivered as part of a research project may be the impetus for subjects to adopt new activity habits with an increased level of exercise.

Problems

The major problems with the project were the small number of subjects, and the time constraints on the length of the intervention, both of which contributed to low statistical power.

Future directions

Subjects were advised that a suitable maintenance program would be a frequency of twice per week with half the number of repetitions or three times per week with a quarter of the number of repetitions. It is intended to do a follow up study to check on LBP symptoms and see whether subjects are using the maintenance program. Also, to see whether the usually sedentary subjects have made lifestyle or exercise habit changes since completing the project. Many subjects did not return their foam supports and it would be interesting to see if these are still in use.

Chapter VI: The stork test on the weight bearing leg as applied to four different stances for the commencement of the test

Introduction

Interest in the biomechanics of the sacroiliac joint (SIJ) has increased in recent years, since this joint has been identified as a possible source of low back and pelvic girdle pain. Jacob and Kissling (1995) established that a small amount of movement occurs at the joint and that the relative direction of the movement between the two joint surfaces can be nutation (anterior rotation of the sacral base) together with posterior rotation of the innominate (os coxa or pelvic bone); or counternutation (a posterior rotation of the sacral base) together with anterior rotation of the innominate. They showed that rotation was inconsistent for a given movement, so that, for example, on forward spinal flexion, it was possible for the sacrum to nutate or counternutate.

The biomechanical modelling of Snijders et al (1993) demonstrated that nutation of the sacrum with posterior rotation of the innominate places the joint in a ‘self-braced’ or locked position that is less vulnerable to the shear forces of vertical loading than is counternutation of the sacrum with anterior rotation of the innominate. In the ‘self-braced’ position, the combined action of transverse muscle fibres, including gluteus maximus would compress the SIJ and facilitate the transmission of forces across the joint. This finding was supported by Richardson and colleagues (2002) who showed that specific activation of the transversus abdominis muscle led to a reduction in SIJ laxity.

Hungerford and Gilleard (1998) described the stork test (also called the one-legged-standing test) on the weight bearing leg as a palpation test that detects movement at the SIJ during the increase of vertical loading forces on the weight transfer to one leg when the other leg is lifted (ie as occurs in gait). The test detects movement of the posterior superior iliac spine (PSIS) on the weight bearing leg relative to the second sacral spinous process.

In a pilot study of healthy subjects, these authors found that during the stork test both innominates rotated posteriorly during ‘toe off’ and anteriorly on return. Whereas, in a group of subjects who were positive on the standing hip flexion/Gillet test or had an asymmetric forward flexion test together with positive pain tests, Sturesson et al (2000) found that both innominates could rotate posteriorly or anteriorly on ‘toe off’.

Hungerford et al (2004) compared stork tests on the weight bearing leg between controls and subjects with posterior pelvic pain (also called SIJ pain) and reported that the innominate rotated posteriorly in the former and anteriorly in the latter. Another difference noted among these subjects (Hungerford et al 2003) involved the timing of the activation of internal oblique and multifidus muscles prior to movement. Compared to controls, this was significantly delayed for posterior pelvic pain subjects with relatively more delay on the symptomatic side.

Hungerford et al (2007) have investigated the test’s interrater reliability and found that using a two point scale, therapists showed high levels of agreement on the pattern of pelvic movement on the weight bearing leg (kappa scores: left $\kappa = 0.67$ percentage agreement 91.9%; right $\kappa = 0.77$ percentage 89.9%). The authors suggested that subject variables, including fatigue, pain and learning ability, might impact on the reliability of repeated measures on the same subject. However, no specific mention was made of the possible influence of the subject’s start position for the test.

The aim of the present study was to examine whether changing the stance of the starting position for the stork test on the weight-bearing leg altered the test outcome.

Methods

The study used a within subjects experimental design with the independent variables being the four different stances for the commencement of the test and the dependent variable being the stork test.

Notices were placed in physiotherapy practices and local community news bulletins in Nowra NSW asking for volunteers. The exclusion criteria were stroke, spinal fusion, significant scoliosis, antalgic gait, hip or knee replacement or significant leg length difference. However, subjects could suffer from a minor ailment or musculoskeletal issue, for example, ‘sore shoulder’ or mild low back pain and be symptomatic or asymptomatic for the test. Seventy-four healthy, mobile adult volunteers, consisting of 19 men aged 49.8 ± 16.3 years (median 51 years) and 55 women aged 50.8 ± 13 years (median 51 years) took part in a series of stork tests that commenced from four different stances. The Human Research Ethics Committee University of Technology Sydney approved the study and subjects gave informed consent. All data was collected between 14th and 24th April 2008. Table 6.1 shows age range and gender breakdown for the group.

Age range	Men	Women
<30	3	7
30 – 49	7	16
50 - 70	8	29
>70	1	3
all subjects	19	55

Table 6.1: Age range and gender breakdown of subjects

To avoid changes in the measurement method, all tests were undertaken by the same researcher who had five years experience in using the stork test. All tests were videoed for later analysis. Subjects stood on a solidly built platform 125mm in height and the tester knelt on the floor behind the subject. Subjects stood in front of a screen made from ‘natural/’cream coloured calico and were illuminated with a diffused spot light and amber side lighting to enhance skin tones. Using a spirit level, the camera was aligned horizontally to avoid parallax error. The area filmed was a dorsal view from the shoulder blades to the calf. Depending upon the subject’s height the region varied from the superior aspect of the scapula to midway down the scapula and from the lower calves to the ankles. Women had their shirts rolled up close to the bra strap level and men removed their shirts.

The four stances for commencement of the test were:

Stance *a*: body weight already transferred to one foot with the toe of the lifting leg resting on the floor as used by Sean Gibbons (personal communication 2007).

Stance *b*: feet close together, with a similar distance between the feet as in Stance a, but the body weight evenly distributed over two feet.

Stance *c*: feet 'hip width apart', the legs were directly below the pelvis and the feet approximately 100mm apart (depending on leg length and height of subject), with the body weight distributed over both feet.

Stance *d*: feet 'shoulder width apart' or a comfortable wide stance with the feet approximately 220mm apart (depending on leg length and height of subject) and the body weight distributed over both feet.

The only difference between stances *b*, *c* and *d* was the distance between the feet as the weight was evenly distributed over both feet, whereas, Stance *a* had the weight already transferred and the toes of the lifting leg resting on the floor.

Although Hungerford et al (1998) noted that minimal rotation occurred after the initial rotation, Stance *a* was included because Gibbons, in a personal communication (2007) reported finding that nutation or counternutation can still occur on the lift, even though the majority of weight has been transferred prior to this. It was decided to include Stance *a* because this interesting observation warranted further investigation and was compatible with the current research design.

Each subject was similarly briefed about the four starting positions and the video process. Subjects were asked not to change the position of the weight bearing leg prior to the lift. They were instructed to lift to 90º of hip-flexion with 90º of knee-flexion and return to the starting position. The order of the four stances for individual subjects was selected by drawing a card from a series of cards, which listed different orders of stances on each and this was changed every six subjects. In addition, the weight bearing leg used for the commencement of the test was changed at the commencement of each video session (usually 13 to 16 subjects per session).

Each stance was identified by a number (1 through to 296), which was written onto a label and placed on the subject's bottom or back prior to the test. The subject was then videoed in the starting stance, which was maintained until the tester, having moved into position behind the subject, instructed the subject to lift the leg. On three occasions a test had to be repeated when the subject misunderstood the instruction or overbalanced, otherwise each test was performed only once on each side for each stance.

The test was taken on the weight-bearing leg on the lift. If the test was taken on the right leg, the tester rested the thumb of the right hand on the posterior superior iliac spine (PSIS) and the rest of the hand on the right innominate. The left thumb was placed on the second sacral spinous process (S2). The subject was instructed to lift the left leg. If the test was taken with the left leg weight bearing, the tester rested the thumb of the left hand on the left PSIS and the thumb of the right hand on S2 and the subject lifted the right leg. To clearly distinguish the thumb position on the screen, both thumbs had strips of black tape placed along the dorsal side from the tips of the nails to the carpometacarpal joints.

The test was recorded as negative if there was no movement of the upper thumb or it moved in a caudal direction. The test was recorded as positive if the upper thumb moved cephalad. Although palpation gave sensitive feedback, a result was not recorded because the study was based upon the careful analysis of the DVD record. The DVDs were reviewed on a computer screen with horizontal lines placed on the screen in order to assess vertical movement. Consistency of test results was recorded across the four stances for each subject.

Statistical analyses included:

- Kappa tests for consistency of stance pairs
- Chi-squared Goodness of Fit for independence of stance outcomes
- Followed by identifying statistically significant cells in the Chi-square table using the Maximum Likelihood Chi-square Statistic (G^2), which involved sequential partitioning of the overall Chi-square into orthogonal components with one degree of freedom (Conover 1999, Agresti 2002, Weaver 2008)

Results

There were four possible results for each of the four stances: a pair of negative results, a pair of positive results and either positive or negative on the left with negative or positive on the right. From the results it was evident that:

- the thumb on the innominate could rise, lower or remain at the same level
- the thumb on the sacrum could rise, lower or remain at the same level
- these movements could be independent

Tables 6.2, 6.3 and 6.4 summarise the consistency of results for individual subjects across the four stances taking into account the relative movement of both thumbs. Tables 6.2 and 6.3 show the results for the innominate thumb moving cephalad on the lift. In Table 6.2 the movement of the sacral thumb was ignored, so that all cephalad movements of the innominate thumb were recorded as positive. In Table 6.3, movement of the sacral thumb cephalad was included. Fifteen subjects had results where the innominate thumb and the sacral thumb rose together, so that the distance between the thumbs stayed the same or reduced and these results were recorded as negative in Table 6.3, whereas they had been recorded as positive in Table 6.2. Table 6.4 contains the results for caudal movement of the sacral thumb with the innominate thumb either moving cephalad or staying at the same level on the lift, so that the distance between the thumbs increased

In Table 6.2, the cephalad movement of the innominate thumb results show there were consistent results across four stances for 21 subjects. There were consistent results across three stances for 23 subjects, with a change on one side on the other stance for 18 subjects and a change on both sides for five subjects. There were consistent results across two stances for 28 subjects. Note that with four stances involved, it was possible for the one subject to have two pairs of consistent stances (for example *a* with *b* and *c* with *d*; *a* with *c* and *b* with *d*; or *a* with *d* and *b* with *c*). This was the case with 15 subjects, reflecting a change on two sides across the other two stances. The remaining subjects included 12 with a change on three sides and one with a change on four sides. Two subjects had completely inconsistent results across the four stances.

Kappa was used to examine the consistency of results between the stance pairs for the four stances in Table 6.2. Consistency was poor for *ab, ac, ad* and *bd,* with Kappa values ranging from -0.03 to + 0.17 (i.e. κ < 2 poor, 2.1 - 4 fair, 4.1 - 6 moderate, 6.1 - 8 good, 8.1 – 1 very good). Kappa values were fair for *bc* and *cd*, 0.32 and 0.34 respectively. Note that as *c* was the intermediate foot placement between *b* and *d*, it was expected that consistency would be better than fair.

Stance *a* was least likely to be included among the consistent results (Table 6.2). For example, this was the case with 15 of the 23 subjects who were consistent across three stances; and for 14 of the 16 subjects with consistent results across two stances and a change on two or three sides across the other two stances.

For the 23 subjects who had consistent results for three stances, Chi-squared analysis showed that Stance a was overly represented as the inconsistent stance [$\chi^2_3 = 23.09$, $p < 0.0001$: post hoc analysis G^2 (df = 1, n = 23) = 10.3, p = 0.001327]. It was expected that if the majority of rotation occurred before 'toe off', there would be subjects with positive results from Stance *b* who would have negative results from Stance *a*. Although this was the case with four subjects, eight subjects showed the opposite pattern i.e. negative results from Stance *b* with positive results from Stance *a*.

The stork test was negative across all stances for 20 subjects (Table 6.2) and only one of the 74 subjects was negative on stances *a* and *d* with a positive result on stances *b* and *c*. Thirty were negative on stances *b* and *c* and had one or more positive results on the other two. (Table 6.2 follows over the page)

<table>
<tr><td>Consistent Result Four Stances</td><td colspan="4">Consistent Result Three Stances</td><td colspan="7">Consistent Result Two Stances</td><td>Inconsistent Result Four Stances</td></tr>
<tr><td>21</td><td colspan="4">23</td><td colspan="7">28</td><td>2</td></tr>
<tr><td rowspan="6"></td><td colspan="4">Change on</td><td colspan="7">Change on</td><td rowspan="6"></td></tr>
<tr><td colspan="2">One Side</td><td colspan="2">Two Sides</td><td colspan="3">Two Sides</td><td colspan="2">Three Sides</td><td colspan="2">Four Sides</td></tr>
<tr><td colspan="2">18</td><td colspan="2">5</td><td colspan="3">15</td><td colspan="2">12</td><td colspan="2">1</td></tr>
<tr><td colspan="4">Consistent Result from Stance</td><td colspan="7">Consistent Result from Stances</td></tr>
<tr><td>abc</td><td colspan="2">abd</td><td>bcd</td><td>ab/cd</td><td>ac/bd</td><td>ad/bc</td><td>ad</td><td>bc</td><td>bd</td><td>cd</td></tr>
<tr><td>6</td><td colspan="2">2</td><td>15</td><td>4</td><td>1</td><td>7</td><td>2</td><td>6</td><td>1</td><td>7</td></tr>
</table>

Table 6.2: Consistency of results across the stances for cephalad movement of the innominate thumb

In Table 6.3, the cephalad movement of the innominate thumb without cephalad movement of the sacral thumb results show there were consistent results across four stances for 26 subjects. There were consistent results across three stances for 23 subjects, with a change on one side on the other stance for 20 subjects and a change on both sides for three subjects. There were consistent results across two stances for 25 subjects with a change on two sides across the other two stances for 14 subjects, across three sides for ten subjects and four sides for one subject. No subjects had completely inconsistent results.

Kappa was used to examine the consistency of results between the stance pairs for the four stances in Table 6.3. Consistency was poor for *ab*, *ac*, *ad*, *bc* and *bd*, with Kappa values ranging from -0.02 to + 0.18. Kappa values were fair for *cd*, 0.31.

Again, Stance *a* was least likely to be included among the consistent results, being absent for 13 of the 23 subjects consistent across three stances; and for 9 of the 13 subjects with consistent results across two stances and a change on two or three sides across the other two stances.

For the 23 subjects (Table 6.3) who had consistent results for three stances, Chi-squared analysis showed that Stance a was again significantly more likely to be the inconsistent stance [χ^2_3= 13, p<0.005: post hoc analysis G^2 (df = 1, n = 23) = 16.48, p < 0.0001]. However, this time there were 17 subjects who were positive from Stance *b* and negative from Stance *a*, whereas only four subjects showed a reverse pattern.

The stork test was negative across all stances for 26 subjects (Table 6.3). Four of the 74 subjects had a negative result on stances *a* and *d* with a positive on stances *b* and/or *c*. Twenty six were negative on stances *b* and *c* with one or more positive results on stances *a* and *d*.

<table>
<tr><td>Consistent Result Four Stances</td><td colspan="4">Consistent Result Three Stances</td><td colspan="8">Consistent Result Two Stances</td><td>Inconsistent Result Four Stances</td></tr>
<tr><td>26</td><td colspan="4">23</td><td colspan="8">25</td><td>0</td></tr>
<tr><td rowspan="6"></td><td colspan="4">Change on</td><td colspan="8">Change on</td><td rowspan="6"></td></tr>
<tr><td colspan="2">One Side</td><td colspan="2">Two Sides</td><td colspan="3">Two Sides</td><td colspan="3">Three Sides</td><td colspan="2">Four Sides</td></tr>
<tr><td colspan="2">20</td><td colspan="2">3</td><td colspan="3">14</td><td colspan="3">10</td><td colspan="2">1</td></tr>
<tr><td colspan="4">Consistent Result from Stance</td><td colspan="8">Consistent Result from Stances</td></tr>
<tr><td>abc</td><td>abd</td><td>acd</td><td>bcd</td><td>ab/cd</td><td>ac/bd</td><td>ad/bc</td><td>ab</td><td>ad</td><td>bc</td><td>bd</td><td>cd</td></tr>
<tr><td>5</td><td>2</td><td>3</td><td>13</td><td>5</td><td>1</td><td>6</td><td>2</td><td>2</td><td>4</td><td>1</td><td>4</td></tr>
</table>

Table 6.3: Consistency of results across the stances for cephalad movement of the innominate thumb without cephalad movement of the sacral thumb

A comparison of the findings in Tables 6.2 and 6.3 shows a tendency towards greater consistency across the stances in Table 6.3. No subjects had completely inconsistent results and there were three fewer subjects with consistent results across two stances. For those with consistent results across three stances, two more subjects had a change on one side rather than both sides. Five more subjects had completely consistent results across all stances.

In Table 6.4, the caudal movement of the sacral thumb without caudal movement of the innominate thumb results show there were consistent results across four stances for 12 subjects. There were consistent results across three stances for 25 subjects, with a change on one side on the other stance for 21 subjects and a change on two sides for four subjects. There were consistent results across two stances for 35 subjects, with a change on two sides across the other two stances for 19 subjects and across three sides for 16 subjects Two subjects had completely inconsistent results.

Kappa was used to examine the consistency of results between the stance pairs for the four stances in Table 6.4. Consistency was poor for *ab*, *ac*, *ad*, *bd* and *cd*, with Kappa values ranging from -0.06 to + 0.16. Kappa values were fair for *bc*, 0.26.

Among the 25 subjects (Table 6.4) with consistent results for three stances and a different result on the fourth stance, Chi-squared analysis showed no significant difference between the stances ($\chi^2_3 = 3$, p = 0.39). This finding was unlike the findings shown in Tables 6.2 and 6.3. (Table 6.4 follows over the page)

<table>
<tr><td>Consistent Result Four Stances</td><td colspan="4">Consistent Result Three Stances</td><td colspan="9">Consistent Result Two Stances</td><td>Inconsistent Result Four Stances</td></tr>
<tr><td>12</td><td colspan="4">25</td><td colspan="9">35</td><td>2</td></tr>
<tr><td rowspan="6"></td><td colspan="4">Change on</td><td colspan="9">Change on</td><td rowspan="6"></td></tr>
<tr><td colspan="2">One Side</td><td colspan="2">Two Sides</td><td colspan="3">Two Sides</td><td colspan="4">Three Sides</td><td colspan="2">Four Sides</td></tr>
<tr><td colspan="2">21</td><td colspan="2">4</td><td colspan="3">19</td><td colspan="4">16</td><td colspan="2">0</td></tr>
<tr><td colspan="4">Consistent Result from Stances</td><td colspan="9">Consistent Result from Stances</td></tr>
<tr><td>abc</td><td>abd</td><td>acd</td><td>bcd</td><td>ab/cd</td><td>ac/bd</td><td>ad/bc</td><td>ab</td><td>ac</td><td>ad</td><td>bc</td><td>bd</td><td>cd</td></tr>
<tr><td>6</td><td>3</td><td>9</td><td>7</td><td>2</td><td>4</td><td>4</td><td>5</td><td>3</td><td>3</td><td>6</td><td>5</td><td>3</td></tr>
</table>

Table 6.4: Consistency of results across the stances for caudal movement of the sacral thumb without caudal movement of the innominate thumb

Unlike the findings shown in Table 6.2 and Table 6.3, there was no particular pattern apparent across the stances in Table 6.4. In addition, results included relatively fewer subjects (12) consistent across the four stances (21 in Table 6.2 and 26 in Table 6.3) and more subjects (35) who were consistent across two stances (28 in Table 6.2 and 25 in Table 6.3). Figure 6.1 is a summary of the consistent results across Tables 6.2 to 6.4.
(Figure 6.1 follows over the page)

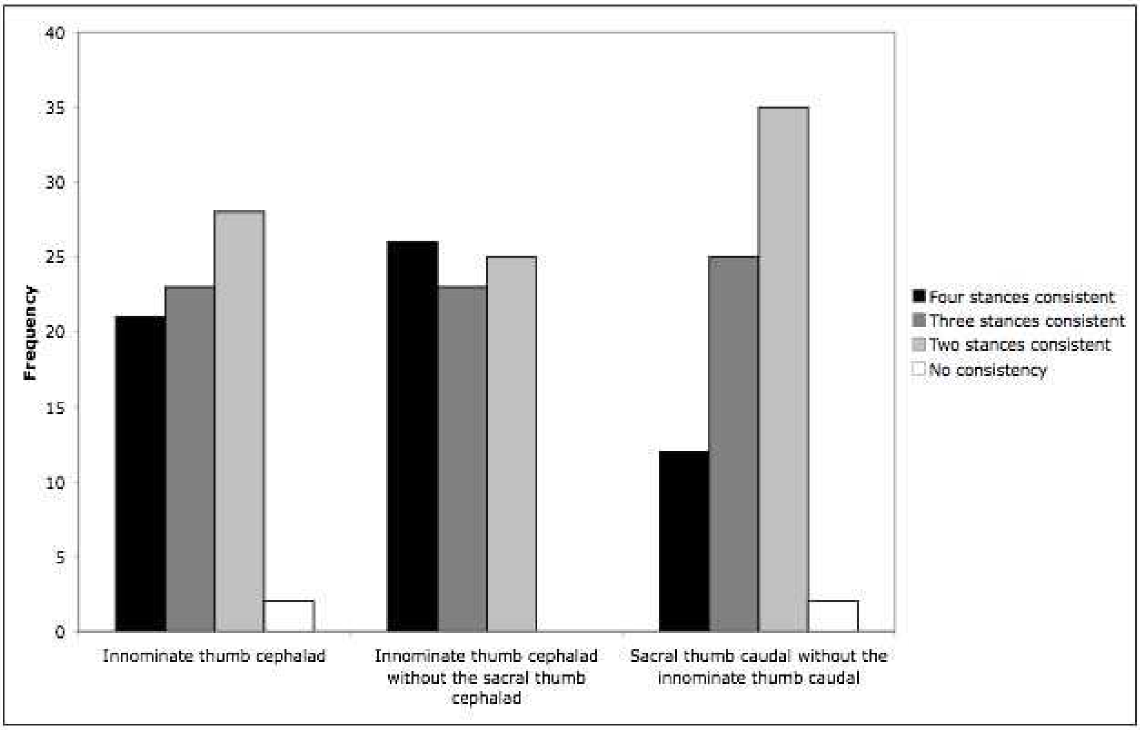

Figure 6.1: Consistent stork test results across the stances

Overall when results were consistent across stances, they were more likely to be negative. For example among the consistent across all stance results, there was only one positive result and that was on both sides (Table 6.2); among consistent results across three stances, there were 15 positive results (two in Table 6.2, three in Table 6.3 and nine in Table 6.4); and for the consistent results across two stances, a total of 65 positive results (21 in Table 6.2, 20 in Table 6.3, 24 in Table 6.4) on one or both sides.

In summary, the starting stance influenced the outcome of the stork test with more than 64% of subjects failing to have consistent results across all four stances and Kappa values showed that consistency was, at best, only fair between the stance pairs.
The results also showed:

- The sacral thumb could move in the cephalad direction in tandem with the innominate thumb, thereby either maintaining or diminishing the distance between the thumbs. This led to a change in the stork test reading from positive to negative

- The sacral thumb could move in the caudal direction without the innominate thumb moving in tandem, thereby increasing the distance between the thumbs. This led to a change in the stork test reading from negative to positive

As most subjects were females in the 41 – 60 age group, it was not possible to conduct a meaningful statistical analysis with respect to age group or gender.

Discussion

Most subjects' results were NOT consistent across all four stances. As noted above, Kappa values were at best, fair. This was the case whether or not the reading of the test took into account the movement of the sacral thumb as well as the innominate thumb. From Table 6.2 and Table 6.3, stance *a* was the most likely to yield an inconsistent result however, this was not the case in Table 6.4.

The lack of consistent results could indicate that the relative contribution of muscles that compress the SIJ may vary with the loads and levers that alter with the change in distance between the feet. In addition, the 'feed forward' mechanism to 'lock' the SIJ may work better in some stances than in others and this may vary with the individual's postural habits and patterns.

Figure 6.2 is a comparison between the positive results for the innominate thumb moving cephalad and the sacral thumb moving caudal by stance. On stance *a*, the innominate thumb was more likely to move cephalad (41 subjects) than the sacral thumb move caudal (15 subjects). On stances *b* and *c* the sacral thumb was more likely to move caudal (47 subjects and 37 subjects respectively) than the innominate thumb move cephalad (16 and 17 subjects respectively). On stance *d*, which involved the greatest distance for load transfer and the greatest difficulty for balance during the transfer, the results were more even (36 and 35 subjects respectively). However, when looking at the movement of the innominate and sacral thumbs cephalad together, this was most likely to occur on stance *d*, where it occurred nine times, and least likely to occur on stance *b*, where it occurred once.

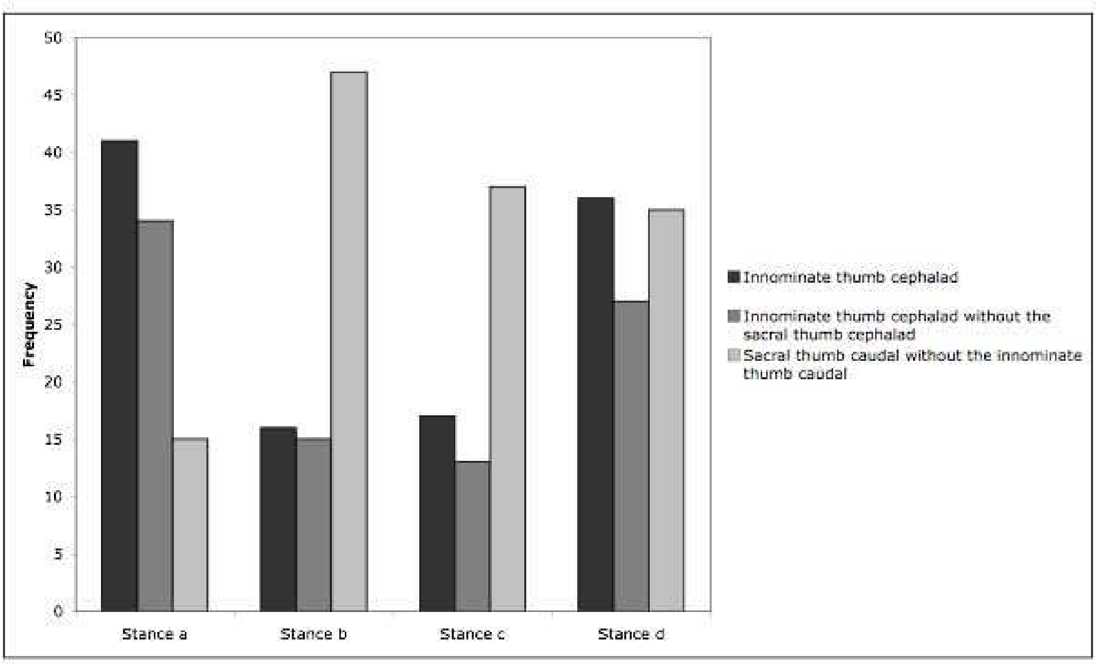

Figure 6.2: Positive stork test results across the stances

Overall, the bilateral results for the cephalad movement of the thumb on the innominate show that a positive result for the right side (more than 65%) occurred more commonly than the left (less than 35%). However, on the caudal movement of the thumb on the sacrum results, it was evenly spread between the sides (49.5% left and 50.5% right).

When results were consistent across the four stances, they were negative, except for one subject, whose result was recorded as positive in Table 6.2, but then negative in Table 6.3. For this subject, the innominate thumb rose and the result was recorded as positive in Table 6.2, but because the sacral thumb also rose (the distance between the thumbs did not increase), this was recorded as negative in Table 6.3. The consistency of results found to be negative suggest that stability and consistency may be related, although this may not be true of a less healthy and mobile population.

That there was only one subject with a positive result across all stances suggests that most subjects will have a stance where they will register a negative test. It is possible that this stance could be used in a rehabilitation program as the most appropriate position to commence exercises in standing. Snijders et al (1993) noted that tension in the lumbodorsal fascia could affect the ‘self bracing’ mechanism of the SIJ and it has been noted in a clinical setting that raising the arm of the weight-bearing leg above the head and straightening the elbow to tension the thoracolumbar fascia may be used to change a stork test result and can be useful in a rehabilitation program.

Although the four standardised stances for commencing the stork test were somewhat artificial, the results indicate that the distance between the feet may influence the outcome, especially in those who have a positive result. In addition, a comparison of the positive results across the tables (see Figure 6.2) suggests that movement appears to take place in the innominate thumb and the sacral thumb either individually or together and an increase in distance between the thumbs can occur without the innominate thumb moving cephalad. These results suggest that further investigation of these movements is warranted. However, what is clear is that for a comparable stork test measurement pre and post treatment, the same starting stance should be used and reported in research.

The stork test on the weight bearing leg originated as a palpation test where interpretation focused on the movement of the innominate thumb. To our knowledge, this study is the first that has recorded the palpation process and delayed the interpretation until the permanent pictorial record can subsequently be analysed in a controlled computer based viewing situation with a standardised measurement scale, away from possible influences of the immediate presence of the subject. While it is possible that palpation may have yielded different results to the present visual protocol, the latter method not only minimises subjective factors, but is also a permanent record, that can be reassessed by clinicians who are blinded to the test conditions.

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Appendix I

UNIVERSITY OF TECHNOLOGY SYDNEY

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

Dear ……………………..,

My name is Dorothy Curnow and I am conducting research into mechanical (nonspecific) lower back pain and Pilates based exercises. I am looking for volunteers who suffer from 'sore', 'tired' or aching backs to participate in a movement based study. As this study involves lying on the floor and a set programme of exercises, it is not suitable for those with a clinical history of back pain, a medically diagnosed back problem or who have had previous back surgery. Volunteers should receive a clearance from their General Practitioner before commencing the program.

The purpose of the study is to assess a specific regime of trunk exercises in relation to the 'sore lower back' syndrome suffered by many people.

The study involves a time commitment on the part of participants that will involve:

- An initial screening of approximately 45 minutes on a Saturday at UTS
- Induction and training taking approximately 1 hour on a Saturday at UTS
- A home exercise programme of approximately 30 minutes duration to be performed 3 times per week over 6 weeks
- Record keeping of approximately 10 minutes duration to be done once per week over 8 weeks
- An exercise check at weeks 2 and 5 which will take approximately 45 minutes on a Saturday at UTS
- A return of records and a final assessment which will take approximately 1 hour at week 8

All information will be stored securely and treated confidentially according to the UTS Ethics Committee Guidelines. The anonymised data will be used for research purposes and will be discussed with my supervisor and other researchers. If any data is published, it will not be in a form that will enable participants to be identified. If you request, your data can be removed at any stage.

All participants may withdraw at any point in the programme and without giving any reason. One of the problems in assigning exercises is that they may cause or increase discomfort or pain. If this happens, please stop the exercises immediately and inform your General Practitioner and me.

If you cannot remember the exercises, think that you may be doing them incorrectly, or wish to revise them, please contact me and I will be happy to organise a mutually convenient time to go through them with you.

If you have any further questions or concerns or think you would like to take part in the study, please contact me on phone, or email Dorothy.L.Curnow@student.uts.edu.au. Remember, you are under no obligation to take part and you may withdraw at any time. Your data can be removed at your request and if your data is used in any way, it will in a form where you will remain anonymous.

Yours sincerely,

Dorothy Curnow

Appendix II

UNIVERSITY OF TECHNOLOGY SYDNEY

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription
The information you provide will be treated confidentially.

Date …………………….………….

Name ……………………………………………………………………… DOB ……………….
Postal
Address ……………………………………………………………………………………………..

Male / Female ………………… Occupation ……………………………………………………

Phone No. home ……………………… work ……………………… Mobile ……………………

Do you use tobacco (yes/no) Approximately, how many cigarettes per day do you smoke?

Do you have or have you ever been treated for any of the following? Please circle.

Heart disease (yes/no)
Asthma or other respiratory ailment (yes/no)
High blood pressure (yes/no)
Stroke (yes/no)
Arthritis (yes/no)
Kidney disease (yes/no)
Diabetes (yes/no)
Low blood pressure (yes/no)
Vascular disorders (yes/no)
Osteoporosis (yes/no)
Neurological or muscular disorders eg. Multiple sclerosis (yes/no)
If female: Are you aware of being pregnant? (yes/no) Are you within 12 weeks of being post partum? (yes/no)

If you answer yes to the following, please write details in the space provided. If you run out of room please continue on the back of this sheet.

Have you ever been treated for back pain? (yes/no)

………

………

Have you ever been diagnosed as having a back condition? (yes/no)

………

………

Have you ever had back surgery? (yes/no)

………

………

Please write yes against any of the following who have treated your back?

Medical doctor ………………… Physiotherapist ……………………Chiropractor …………………

Osteopath …………………….. Other ……………………………………………….

Appendix III

UNIVERSITY OF TECHNOLOGY SYDNEY

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription Study Instructions

Date …………………………

Name ……………………………………………………………………………..

Wedge size ………………………… Group ………………

The next three appointments are: Week 2 ………………………… At ………………

Week 5 ………………………… At ………………

Week 8 ………………………… At ………………

What are you currently doing for exercise? ……………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Would you describe that exercise as?

Nil Light Moderate Moderately Heavy Heavy

How often do you exercise?

Less than 1 day per week 1 to 3 days per week 4 to 6 days per week Daily

How many times in the average week do you suffer back pain ……………………..

Are there specific activities that precede back pain? What are they? ……………………..

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

<u>Duration</u>

How long is the **shortest** length of time you suffer back pain?

Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long is the **longest** length of time you suffer back pain?
Less than 1 hour   1 to 6 hours   6 to 12 hours   12 to 24 hours   More than 24 hours

How long is the **average** length of time you suffer back pain?
Less than 1 hour   1 to 6 hours   6 to 12 hours   12 to 24 hours   More than 24 hours

Please describe your pain in words ……………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident?
0 1 2 3 4 5 6 7 8 9 10

Please circle or highlight the following:

- **Select three days and times** each week that you will be able to regularly put aside for your programme.

Monday   Tuesday   Wednesday   Thursday   Friday   Saturday   Sunday
………   ………   ………   ………   ………   ………   ………

- **Select one day** each week that you will be able to record details from the previous week.

Monday   Tuesday   Wednesday   Thursday   Friday   Saturday   Sunday

Appendix IV

Name ____ **Date** ____________________

OSWESTRY DISABILITY QUESTIONNAIRE

This questionnaire has been designed to give us information as to how your back or leg pain is affecting your ability to manage in everyday life. Please answer by checking **one box in each section** for the statement which best applies to you. We realise you may consider that two or more statements in any one section apply but please just shade out the spot that indicates the statement ***which most clearly describes your problem.***

Section 1: Pain Intensity

☐ I have no pain at the moment
☐ The pain is very mild at the moment
☐ The pain is moderate at the moment
☐ The pain is fairly severe at the moment
☐ The pain is very severe at the moment
☐ The pain is the worst imaginable at the moment

Section 2: Personal Care (Washing, Dressing, etc.)

☐ I can look after myself normally without causing pain
☐ I can look after myself normally but it causes a little bit of pain
☐ I can look after myself normally but some things always cause pain
☐ It is painful to look after myself and I am slow and careful
☐ I need some help but can manage most of my personal care
☐ I need help every day in most aspects of personal care

Section 3: Lifting

☐ I can lift heavy weights without pain
☐ I can lift heavy weights but it gives me a little bit of pain
☐ Pain prevents me lifting heavy weights off the floor but I can manage if they are conveniently placed e.g. on a table
☐ Pain prevents me lifting heavy weights, but I can lift medium weights
☐ Pain prevents me lifting medium weights, but I can lift light weights
☐ Pain prevents me lifting even light weights

Section 4: Walking

☐ Pain does not prevent me walking any distance
☐ Pain prevents me from walking more than two hours non-stop
☐ Pain prevents me from walking more than one hour non-stop
☐ Pain prevents me from walking more than 30 minutes non-stop
☐ Pain prevents me from walking more than 15 minutes non-stop
☐ Pain allows me to walk less than 15 minutes non-stop

Section 5: Sitting

☐ I can sit in a chair as long as I like
☐ Pain prevents me sitting more than two hours
☐ Pain prevents me sitting more than one hour
☐ Pain prevents me from sitting more than 30 minutes
☐ Pain prevents me from sitting more than 15 minutes
☐ Pain allows me to sit less than 15 minutes

Name ____ **Date** ____________________

Section 6: Standing
- [ ] I can stand as long as I want without pain
- [ ] Pain prevents me from standing more than two hours
- [ ] Pain prevents me from standing more than one hour
- [ ] Pain prevents me from standing more than 30 minutes
- [ ] Pain prevents me from standing more than 15 minutes
- [ ] Pain allows me to stand less than 15 minutes

Section 7: Sleeping
- [ ] My sleep is never disturbed by pain
- [ ] My sleep is occasionally disturbed by pain
- [ ] Because of pain I have less than six hours sleep at a time
- [ ] Because of pain I have less than four hours sleep at a time
- [ ] Because of pain I have less than two hours sleep at a time
- [ ] Because of pain I have less than one hours sleep at a time

Section 8: Social Life
- [ ] My social life is normal and gives me no pain
- [ ] My social life is normal but it causes a little bit of pain
- [ ] Pain has no significant effect on my social life apart from limiting my more energetic interests e.g. sport
- [ ] Pain has restricted my social life and I do not go out as often as I would like
- [ ] Pain has restricted my social life to my home
- [ ] I have no social life because of pain

Section 9: Travelling
- [ ] I can travel anywhere without pain
- [ ] I can travel anywhere but it gives me a little bit of pain
- [ ] Pain is bad but I manage journeys over two hours
- [ ] Pain restricts me to journeys of less than two hours
- [ ] Pain restricts me to journeys of less than one hour
- [ ] Pain restricts me to short necessary journeys of less than 30 minutes

Section 10: Employment/Homemaking
- [ ] My normal homemaking/job activities do not cause pain
- [ ] My normal homemaking/job activities give me a little bit of pain, but I can still perform all that is required of me
- [ ] Some things in my normal homemaking/job activities always give me pain, but I can still perform all that is required of me.
- [ ] I can perform most of my homemaking/job activities, but pain prevents me from performing more physically stressful activities (eg lifting, vacuuming).
- [ ] Pain prevents me from doing anything but light duties
- [ ] Pain prevents me from doing even light duties

Appendix V

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

Initial Assessment Date …………..………………….. **Alignment Prior To Study**

Name ……………………………………………………………..…. DOB ……………..……………….

Phone ……………………………………. Mobile ……………………………………………..….

Pathologies: ……………………………………………………………………………………..

Pain Site: ……………………………………………………………………………………...

Pain Type: ……………………………………………………………………………………….

Pain provocations: ………………………………………………………………………………

Current Exercise: ………………………………………………………………………………..

Handedness ………………………… Height ……………………………………...

Standing Tests

Spine Shape   Neutral   Scoliosis   Elongated S   S   l   C   Other

Post. Pelvis Sagittal Plane **No** **L** **R**
Stork Test Weight Bearing **o** **o**
Upslip clavicle Test

Ant. Pelvis Sagittal Plane **No** **L** **R**
Non-Weight Bearing **o** **o**
Forward Flexion Test

Sitting Tests

Sacral Alignment **Sitting** **L** **R**

Sacral Alignment **Sitting Flexion** **L** **R** **o** **o**
Forward Flexion Test Sitting

Posterior Sacral Glide on **Forward Flexion** **No** **Yes**

Non-inferior Lateral Angle **Sitting Lateral Flexion to**: **L** **R**

Prone Tests

Sacral Alignment **Prone** **L** **R** **o** **o**
Posterior Superior Iliac Spine

Sacral Alignment **Prone Extension** **L** **R** **o** **o**
Posterior Superior Iliac Spine

Anterior Sacral Glide on **Prone Extension** **No** **Yes**

Supine Tests

Anterior ASIS **No** **L** **R**   SIJ Palpation **No** **L** **R**

Wedge Size …………………………….. **Group …………………**

Appendix VI

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I ____ (participant's name) agree to participate in the research project, Altered Motor Control, Posture and the Pilates Method of Exercise Prescription being conducted by Dorothy Curnow, Dept of Health Sciences - Pilates, UTS, PO Box 123, Broadway. NSW 2007 Dorothy.L.Curnow@student.uts.edu.au

I understand that the purpose of this study is to assess the efficacy of various exercise programmes in the treatment of mechanical (nonspecific) lower back pain. Because an exercise programme may cause or increase discomfort or pain I will obtain a clearance from my General Practitioner that I am suitable for such a program before commencing the exercises.

I understand that my participation in this research will involve:

- An initial screening of approximately 1 hour on a Friday at UTS
- Induction and training taking approximately 1 hour on a Friday at UTS
- A home exercise programme of approximately 40 minutes duration to be performed 3 times per week over 6 weeks
- Record keeping of approximately 10 minutes duration to be done once per week over 8 weeks
- An exercise check at weeks 2 and 5 which will take approximately 45 minutes on a Friday at UTS
- The possibility of further exercise checks if I request them
- A return of records and a final assessment which will take approximately 1 hour at week 8

If I feel that the program is causing or increasing any symptoms, discomfort or pain I will stop the exercises immediately and inform my General Practitioner and Dorothy Curnow.

I am aware that I can contact Dorothy Curnow if I have any concerns about the research. I also understand that I am free to withdraw my participation from this research project at any time I wish, without consequences, and without giving reason.

I agree that Dorothy Curnow has answered all my questions fully and clearly.

I agree that the research data gathered from this project may be published in a form that does not identify me in any way.

__________________________________   _____/_____/______

Signature (participant)   Date

__________________________________   _____/_____/______

Signature (researcher)   Date

Note: This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer, ph: 02 – 9514 9615, Research.Ethics@uts.edu.au, and quote the UTS HREC reference number 2005-100. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix VII

Exercises for: Altered Motor Control and the Pilates Method of Body Conditioning

Name ……………………………………………………………………… Date ………………………

Ring Dorothy Curnow 0437 323 485, if you have any problems or need advice.

Please do the exercises ***slowly*** and in order.

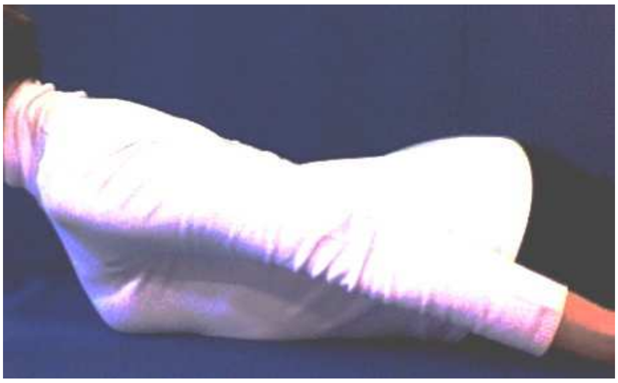
Hand Position for Head Hold

Curl Up

- Lie supine with the legs straight and together. If your back is uncomfortable, place a firm cushion or a couple of phone books under your feet. If your neck is uncomfortable, place a cushion under your head
- Place your hands behind your head in a position that does not strain the neck (see photo)
- Gently draw your hip-bones together. Imagine them meeting in the middle of your stomach
- On the exhale of breath, send your bottom ribs towards your hips till your head and shoulders come off the floor. Imagine your ribs touching your hips
- On the inhale of breath, return to the floor
- Do 20 times; have a rest; repeat

Double Leg Lift Side Lying

- Side lie with the legs straight and together
- Place your head on a cushion or on your lower arm
- Place the upper arm on your side or on the floor in front of you
- Gently draw your hip-bones together
- On the exhale of breath, lift both legs off the floor, sending your ankle bones to the wall below your feet
- At the same time, feel as if you are lifting your waist off the floor
- On the inhale of breath, return to the floor
- Do 20 times on each side; have a rest; repeat



Back Extension

- Lie prone with the legs straight and slightly apart
- Place your forehead on a towel
- Place your hands on your shoulders or down by your sides
- Imagine your hip-bones gently drawing together
- On the exhale of breath, lift your head and shoulders off the floor till you are propped up on your lower ribs
- On the inhale of breath, return to the floor
- Do 20 times; have a rest; repeat

Curl Up with Twist

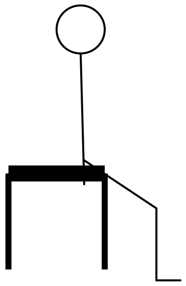
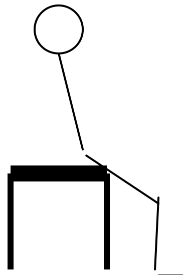
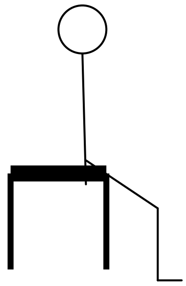
- Lie supine with the legs straight and together. If your back is uncomfortable, place a firm cushion or a couple of phone books under your feet. If your neck is uncomfortable, place a cushion under your head
- Place your hands behind your head in a position that does not strain the neck (see photo)
- Gently draw your hip-bones together. Imagine them meeting in the middle of your stomach
- On the exhale of breath, send your right nipple towards your left hip till your head and shoulders come off the floor at an oblique angle
- On the inhale of breath, return to the floor
- Repeat, sending your left nipple to your right hip
- Do 10 sets of 1 on each side; have a rest; repeat

UNIVERSITY OF TECHNOLOGY SYDNEY

Postural Exercise



Start Erect **Hinge Back** **Return to Erect**

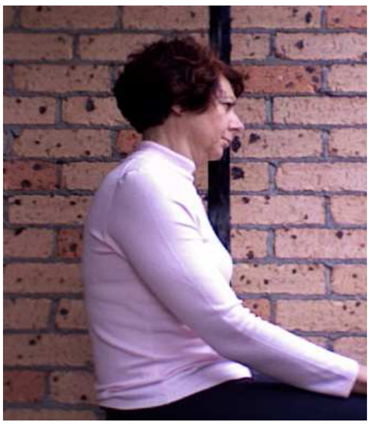




Start Erect **Hinge Back** **Return to Erect**

- Sit very tall on a back-less stool or the side of a chair, with your feet on the floor. Imagine you have an iron rod between the front of your ribs and your pubic bone and it will not bend
- Keeping the shoulders positioned over the hips with the back straight, slowly move the pelvis and shoulders backwards about 10 degrees and pause
- Gently draw your pubic bone off the chair
- Return to erect
- This is a hinge action of the pelvis on the thighs and it is difficult to execute the movement in the pelvis while keeping the rib cage and the shoulders correctly aligned over the moving pelvis
- Do 10 times have a rest and repeat

Incorrect Leaning Back Positions

Bending Back



Slumping Back

Appendix IX

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription FAQ

What is supine?
- Supine is lying on your back

What is prone?
- Prone is lying on your stomach

Breathing

How should I breathe?
- You should breathe ‘in’ through the nose and ‘out’ through the mouth

Does it matter if I do the wrong breathing pattern on the exercises?
- No; as long as your breathing is relaxed and you do not hold your breath

How can I use my breathing to help me keep my stomach controlled?
- You should start the exhale before you commence the movement

Curl Up and *Curl Up with Twist*

What should I do if I have neck strain?
- Check that your hands are really lifting upwards and not just squeezing your head
- Use a higher cushion under your head
- Try interlocking your fingers and placing your hands behind your head so that the heels of the hands are squeezing your head at ear level. It is a gentle nutcracker movement

What part of the body leads the movement?
- The ribs lead the movement. Feel that the ribs are pulling the head up and not the other way round
- Feel that you are shortening the space between the front of your ribs and your pelvis
- Reach your ribs to your pelvis and not your pelvis to your ribs

As I gently draw the hip bones together before starting the exercise, should I feel my stomach pull in or push out?
- You should feel your stomach pull in. It is important not to push out or let go of the feeling that your hip-bones are moving together. If you place a hand on your lower abdomen, it should stay still and not lift up or bulge when you move

What other images can I use to help me do the exercise correctly?
- Once you have drawn your hip-bones together, imagine a peg holding them together
- Narrow the top of the pelvis

Should I ‘tense’ my stomach?
- No: if by that you mean that it lifts up

When do I draw my hip-bones together?
- Before you start the movement; then they stay together through the movement

What should I do if I can’t do this?
- Try initiating the movement by drawing up through the front of the pelvic floor or feel that you are drawing your stomach away from your pubic bone

What should I feel when I do this exercise?
- You should feel your stomach muscles. Often, this will be the area just below the ribs

Double Leg Lift Side Lying

What should I do if I have pain in my lower back?

- Move your legs slightly forward of centre
- Check that the legs are straight, but the knees are not locked back

Where should I have my top arm?

- Along the top of your body, unless you wobble; then, put your hand on the floor in front of your body

What should I do if my hip is sore lying on it?

- Put extra padding under your side Eg. An extra mat or flat cushion

How do I stop my waist pressing down as I lift my legs?

- You should try to feel as if your legs are growing longer as they lift. Reach your legs to the opposite wall

What should I feel when I do this exercise?

- You should feel the side area of your waist. It should feel as if there is room between your waist and the floor. Imagine you have a little tunnel between your waist and the floor. If you put your fingers under your waist, there should be no increase in pressure on your fingers when you lift your legs

Back Extension

What should I do if my lower back feels uncomfortable?

- Reach your bottom bones to the wall behind you
- Imagine you have an iron rod between the front of your ribs and your pubic bone and don't let it bend when you lift your head and shoulders
- Use your abdominal muscles to slightly tilt your pubic bone towards your ribs or gently press your pubic bone down into the mat
- If you have your hands on your shoulders, lead with your elbows or reach the back of your arms to the wall behind
- Put a flat cushion under your waist
- Don't lift so high
- Be careful your neck is staying relaxed and your eyes look downwards

How high do I lift?

- You should lift as high as you feel comfortable and not so high that you feel it strongly in the lower back

What should I feel when I do this exercise?

- You should feel the upper back muscles below the shoulder blades

Curl Up with Twist

Should I do all the twist movements to one side and then the other side?

- No; alternate sides. Do one on one side and the next to the other

Should I start twisting from the beginning of the movement?

- Not necessarily: start the movement as if you are doing a plain *Curl Up* and then twist. Either, reach the right ribs to the left side of the pelvis or the left ribs to the right side of the pelvis
- Remember to keep drawing the hip-bones together
- Do not let the stomach lift/bulge

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

FAQ continued

The Wedge

How long should I stay on the wedge?

- After positioning the wedge in the correct position and totally relaxing, stay there approximately 3 minutes.

Can I stay longer, if I want?

- Yes; but no longer than 5 minutes

What should I do if the wedge cuts across my lower back?

- You need to position the wedge higher up your back, because it should be in a position where it cuts across your lower ribs; but, does not feel uncomfortable

What should I do if I find myself slipping back?

- You should use a higher cushion under your head

Where are my legs?

- Your legs should be placed over a stool or chair

What should I feel when I do this exercise?

- You should feel relaxed and comfortable, even though it might feel unusual
- It should feel more comfortable the longer you stay there; but, do not stay longer than 5 minutes. If it feels more uncomfortable the longer you stay there, contact Dorothy and discontinue using the wedge

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription
FAQ continued

Postural Exercise

Am I doing this exercise properly if I find it easy to rock backwards and I can go back a long way?

- Probably not; the movement in the pelvis is relative to the legs; whereas, the movement in the shoulders is only to maintain alignment over the pelvis. The most common fault is for people to combine leaning back slightly in the shoulders when moving the pelvis. The movement then feels like ‘rocking’ and you will lose the ‘iron rod’ feeling between the front of the ribs and the pubic bone
- The distance between the ribs and the pelvis should not change. You can see if this happens by putting your thumbs on your ribs and your middle fingers on your pelvis and then lean back
- Reach the top of your head to the ceiling as you hinge back

What other images can I use to help me do the exercise correctly?

- Gently draw the posterior hip bones together while sending the bottom bones apart before starting the exercise and maintain it through the exercise
- Imagine a ruler. If one end moves, the whole ruler moves, but the relationship between the two ends stays the same

What should I feel when I do this exercise?

- You should feel a tightness in the abdominal muscles as they work hard to maintain the position
- If you do not feel the muscles work spontaneously, you are not doing it correctly. You are probably leaning back from the shoulders more than moving the whole body back from the hips

Appendix X

UNIVERSITY OF TECHNOLOGY SYDNEY

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription Recording Sheets

Date ……………………….…

Name ………………………………………………………………………………..

Your next three appointments are: Week 2 …………………………. At ……………….

Week 5 …………………………. At ……………….

Week 8 …………………………. At ……………….

Are there specific activities that precede back pain? What are they? ……………………..

……………………………………………………………………………………………

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<u>Please circle or highlight the following</u>:

- **Select three days and times** each week that you will be able to regularly put aside for your programme.

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

……… ……… ……… ……… ……… ……… ………

- **Select one day** each week that you will be able to record details from the previous week.

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Please contact Dorothy Curnow on 0437 323 485 or Dorothy.L.Curnow@student.uts.edu.au
If you have any questions or would like to review the exercises or change an appointment time.

UNIVERSITY OF TECHNOLOGY SYDNEY

Recording of Details – **Week 1** – Date **……………..……………**

How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration

How long was the **shortest** length of time you suffered back pain in the previous week?

Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?

Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?

Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?

0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?

0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?

0 1 2 3 4 5 6 7 8 9 10

Activities

During the previous week have you participated in activities that usually precede back pain?

…………………….

If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?

0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?

Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Recording of Details – **Week 2** – Date **……………..……………**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain? …………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Recording of Details – **Week 3 –** Date **……………..……………**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain? …………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Recording of Details – **Week 4** – Date **…………….……………**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain? …………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ………………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Recording of Details – **Week 5 –** Date **……………..……………**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain? …………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ………………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Reminder: Stop doing your exercises at the end of Week 6. Only do recording for Weeks 7&8.

<u>Recording of Details</u> – **Week 6** – Date **……………..……………**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

<u>Duration</u>
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

<u>Intensity</u>
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

<u>Activities</u>
During the previous week have you participated in activities that usually precede back pain?
…………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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UNIVERSITY OF TECHNOLOGY SYDNEY

Date ……………………..……

Recording of Details – **Week 7 – No exercises this week**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain?
…………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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Date …………………..……

Recording of Details – **Week 8 – No exercises this week**
How many times in the previous week did you suffer back pain ……………..

On what days did you suffer back pain?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Duration
How long was the **shortest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **longest** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

How long was the **average** length of time you suffered back pain in the previous week?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Intensity
On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **shortest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **longest** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain on the **average** incident in the previous week?
0 1 2 3 4 5 6 7 8 9 10

Activities
During the previous week have you participated in activities that usually precede back pain? …………………….
If so, on a scale of 1 to 10, with 0 being no pain and 10 being the worst possible pain, how would you describe the intensity of pain after those activities?
0 1 2 3 4 5 6 7 8 9 10

How long was the duration of that pain?
Less than 1 hour 1 to 6 hours 6 to 12 hours 12 to 24 hours More than 24 hours

Comment ……………………………………………………………………………………….

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Appendix XI

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

Final Assessment Date …………..………………….. **Alignment Post Study**

Name ……………………………………………………………..…. DOB ……………….…………….

Exercise Start Date ………..………..…… Exercise End Date ………..……..……. No of checks ………………

No/length of breaks …………..……….…… Exercise evaluation ………… Other interventions ………..……

Pain Site: ……………………………………………………………………………………………...

Pain Type: ……………………………………………………………………………………………

Pain provocations: …………………………………………………………………………………

Current Exercise: …………………………………………………………………………………..

Standing Tests

Spine Shape Neutral Scoliosis Elongated S S l C Other

Post. Pelvis Sagittal Plane **No** **L** **R**
Stork Test Weight Bearing o o
Upslip clavicle Test

Ant. Pelvis Sagittal Plane **No** **L** **R**
Non-Weight Bearing o o
Forward Flexion Test

Sitting Tests

Sacral Alignment **Sitting** **L** **R**

Sacral Alignment **Sitting Flexion** **L** **R** o o
Forward Flexion Test Sitting

Posterior Sacral Glide on **Forward Flexion** **No** **Yes**

Non-inferior Lateral Angle **Sitting Lateral Flexion to**: **L** **R**

Prone Tests

Sacral Alignment **Prone** **L** **R** o o
Posterior Superior Iliac Spine

Sacral Alignment **Prone Extension** **L** **R** o o
Posterior Superior Iliac Spine

Anterior Sacral Glide on **Prone Extension** **No** **Yes**

Supine Tests

Anterior ASIS **No** **L** **R**

SIJ Palpation **No** **L** **R**

Wedge Size ……………..…… Group ………..…. To ……………….

Appendix XII

Name ____ **Date** ______________________

Section 11: Frequently performed painful activity

One frequently performed activity that causes me pain is ....

☐ I can perform that activity without pain
☐ I can perform that activity, but experience pain afterwards
☐ I can perform that activity with some discomfort
☐ I can perform that activity with only a little bit of pain
☐ I can perform that activity with a lot of pain
☐ Pain prevents me performing that activity

Appendix XIII

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

Protocols for Exercising and Recording

What should I do if I cannot remember or am unsure how to perform the exercises?

- Contact Dorothy and make an appointment to go through them again. The exercises appear easy, but involve a number of subtleties and are difficult to perform correctly; that is why exercise checks are important. The vast majority of people need two exercise checks before they can perform the exercises correctly

What should I do if I have pain when I perform an exercise or after using the wedge?

- Stop exercising or using the wedge and contact me. I need to check your exercises and/or check that you have the right size wedge

What should I do if I get sick and am unable to exercise for a week or two?

- Keep recording, but add on the extra weeks. It is important that you do 6 weeks of exercises, even if you take longer than the 6 weeks to do that. You will need to photocopy and add some more recording sheets.
- Eg. Week 1 exercises done 3 times
  Week 2 exercises done 3 times
  Week 3 exercises done 3 times
  Week 4 – sick – no exercises done, but keep recording
  Week 5 exercises done 3 times
  Week 6 exercises done 3 times
  Week 7 exercises done 3 times
  Week 8 no exercises to be done – just recording
  Week 9 no exercises to be done – just recording
  In the case above, exercises have been done for 6 weeks and recording done for 9 weeks and not 8 weeks

What should I do if I only miss one session of exercises?

- Just note it on your recording sheet that you have done your exercises twice and not three times that week
- If this happens more than twice, you will need to add on an extra week of exercises

What should I do if I make an appointment time and cannot attend?

- Please contact me as soon as possible. My mobile number is 0437 323 485. This may give someone else the opportunity of using that time and I can reschedule your appointment. Please do not be a ‘no show’, because it is very frustrating and time wasting for other study volunteers and me

Altered motor control, posture and the Pilates method of exercise prescription

Authors - Dorothy Curnow, Jennifer Wyndham, S. T. Boris Choy, Deirdre Cobbin
Faculty of Science, University of Technology, Sydney, Australia
Email: Dorothy.L.Curnow@student.uts.edu.au

Purpose – to determine whether a basic set of Pilates exercises improves pelvic stability as measured by the Stork Test in weight bearing (Hungerford et al, 2004)

- to compare the effects on mild chronic lower back pain (LBP) symptoms of three Pilates regimes: (i) a basic program involving four exercises (ii) a basic program plus a relaxation posture or (iii) a basic program plus a relaxation posture and a postural training exercise.

Relevance – Although Pilates has had a major effect on the exercise industry, there is little direct evidence for its efficacy.

Methods – The study involved a cohort of 48 volunteers with mild chronic LBP all performing a basic set of Pilates exercises before being randomly divided into three equal groups for the addition of other interventions.

Entry assessment: all subjects completed an Oswestry Disability Questionnaire (Victorian Workcover Authority, 2004) in relation to LBP symptoms; recorded frequency, intensity and duration of back pain episodes in an average week; a Stork Test was performed to establish baseline values.

Subjects were taught four basic exercises before being randomly allocated to a specific intervention group (A, B or C). Two of the exercises were performed in supine and involved abdominal muscle contraction and a small degree of trunk flexion. One exercise was performed side lying and involved trunk muscle contraction, but no side flexion. One exercise was performed prone and involved spinal extensor muscle contraction and a small degree of spine extension. Group A received no additional exercises. Groups B and C received a relaxation posture on a specifically designed spinal support to use before the basic exercises. Group C also received a postural training exercise involving hip flexion and eccentric psoas contraction to be performed after the basic exercises. Each exercise in the basic program was performed with 40 repetitions and the postural training exercise was performed with 20 repetitions. Exercises were performed at home three times per week for six weeks. Subjects returned for follow up exercise checks, in weeks 2 and 4.

For eight weeks, subjects recorded the frequency of their back pain in the previous week and whether they had participated in any activities that usually preceded LBP. Using Likert scales, they recorded the intensity and duration of the previous week's pain for the shortest, longest and average episodes.

After eight weeks, subjects received a final assessment where they filled out another Oswestry Disability Questionnaire and were asked whether they had changed their normal exercise routine or received other interventions for LBP. A second Stork Test was performed.

Analysis

Minitab was used to analyse results and provide descriptive statistics. The Sign Test and Wilcoxon Signed Rank Test were used for pre and post comparison of answers. In addition one way ANOVA and regression analysis were used to gauge the effect of gender, body build, age and height.

Results

Oswestry Questionnaire

Pre and post comparison of answers showed only one significant improvement for subjects and that was for question 1 ($p = 0.029$). However there were no significant differences in improvement between the three groups. This was the only question relating to current pain symptoms.

Number of Days Subjects Experienced Pain

Subjects showed a significant improvement ($p = 0.018$) on a comparison between weeks 1 and 6 (the last week of performing exercises). There was also a significant improvement ($p = 0.011$) on a comparison between weeks 1 and 8 (six weeks of performing exercises plus two weeks of no exercises). However there was no difference between the three groups.

Duration of Pain

There was a significant improvement in subjects ($p = 0.02$) on the length of the shortest pain episodes between weeks 1 and 6, but not between weeks 1 and 8 and there was no improvement in the lengths of the longest and average pain episodes.

There was also a significant difference between groups on a comparison between weeks 1 and 6. Group B (the relaxation posture) did much better than Group A and Group C (the relaxation posture and the postural training exercise) did better again (Fig 1).

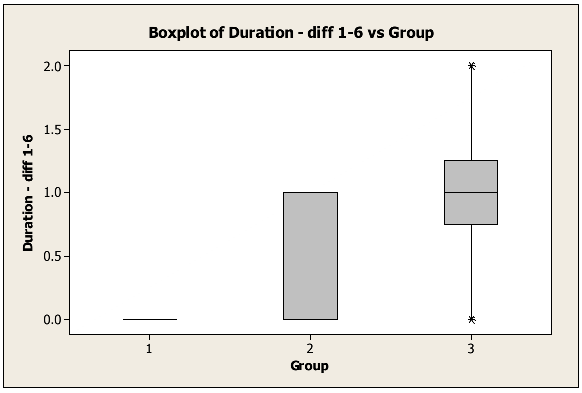

Figure 1

Intensity of Pain

A significant improvement in the intensity of pain across all lengths of pain episodes was recorded for subjects (shortest – $p = 0.006$, longest – $p = 0.0003$, average – $p = 0.002$) on a comparison between weeks 1 and 6. There was also a significant improvement in the intensity of pain on the longest and average duration of pain episodes on a comparison between weeks 1 to 8 (longest – $p = 0.006$, average – $p = 0.046$), but not the shortest duration of pain incidents. In addition, there was a significant difference between groups (Fig 2, 3 and 5).

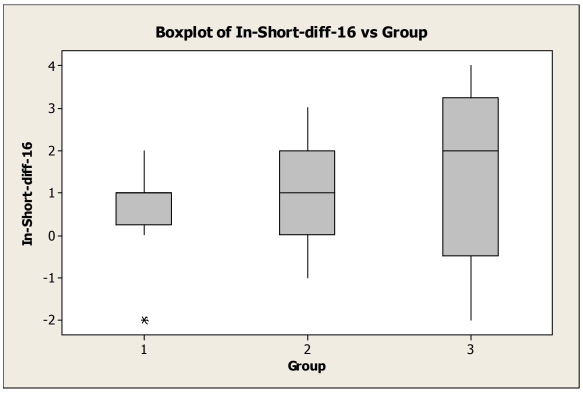

Figure 2

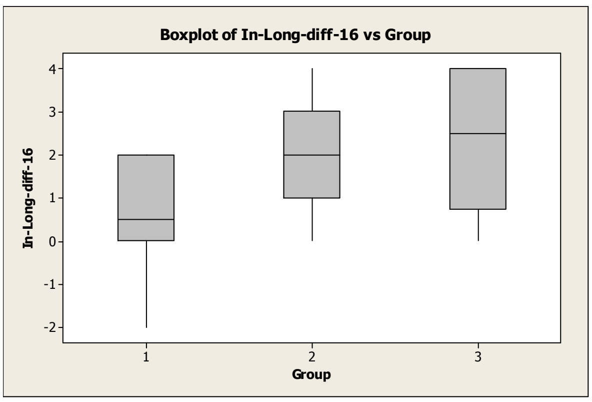

Figure 3

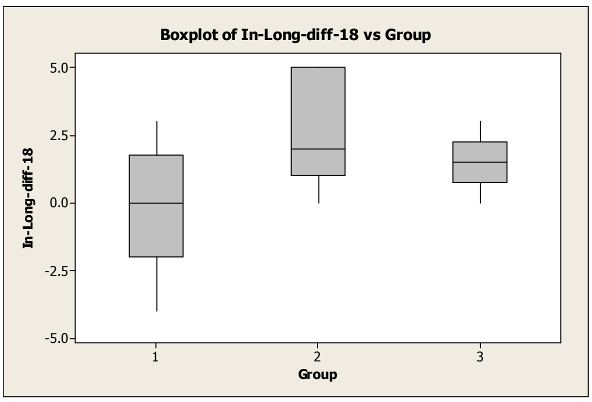

Figure 4

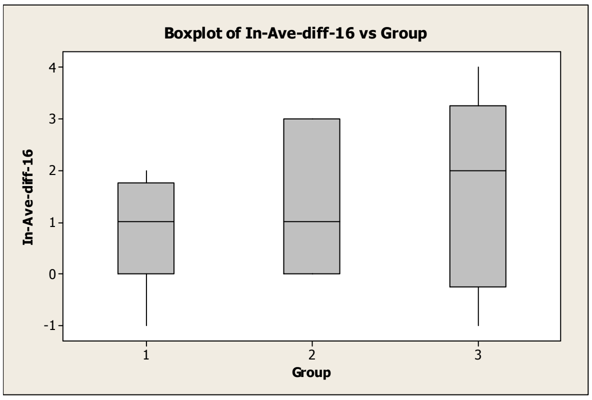

Figure 5

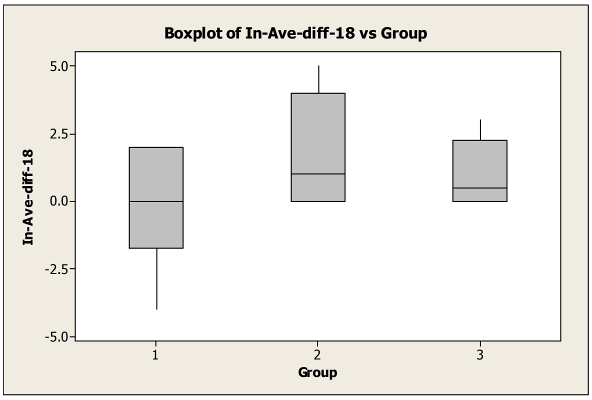

Figure 6

The Stork Test Weight Bearing
A significant improvement (p = 0.0017) in weight bearing pre and post the program was observed and there was a significant difference between groups (Fig 7).

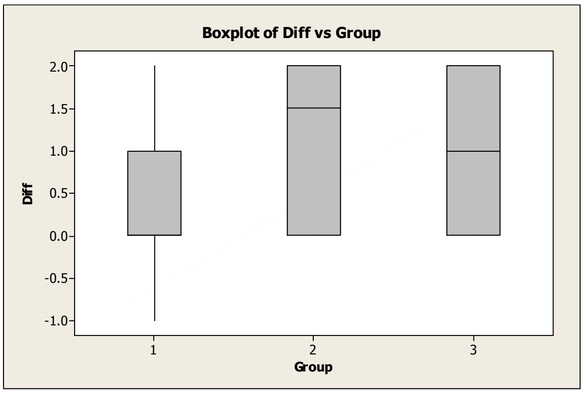

Figure7

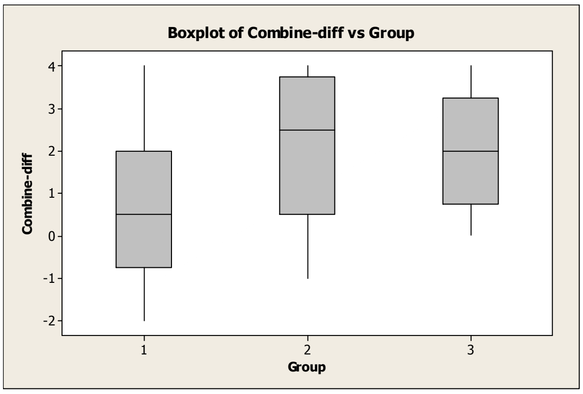

Figure 8

The Stork Test Weight Bearing Combined with Non-Weight Bearing
There was also a significant improvement (p=0.004) pre and post the program and a significant difference between groups (Fig 8).

One-Way ANOVA and Regression analysis showed no difference for age, height, gender or body build.

At 1 June, 22 subjects have completed the program. Nine subjects did not start the program because of time constraint; two subjects were excluded because of clinical considerations and one subject dropped out after doing the exercises once, because she thought her back pain was increased. There were compliance problems with five of the subjects and this included completing only four or five weeks of the exercises and one person having a final assessment eight weeks after the due date.

Summary of results: Preliminary analyses indicate that (a) pelvic stability improved with a correctly performed basic Pilates exercise program (b) addition of a relaxation posture and a postural training exercise improved the outcomes of the basic exercise program as measured by a reduction in the intensity LBP symptoms (c) once the exercises ceased to be performed, the gains in duration and intensity on the short pain episodes were quickly lost.

Non-complying subjects in Group B could possibly explain the difference between groups in Weeks 1-6 in comparison to Weeks 1-8. Those subjects in Group B may have continued to use the relaxation posture during Weeks 7 and 8 because they did not identify it as part of their exercise program. However, the subjects in Group C, because they received the postural training exercise together with the relaxation posture, may have been more likely to identify the relaxation posture as another exercise in the exercise program (Fig 4 and 6).

Because subjects felt stronger, more flexible and thought there was a reduction in their pain symptoms, all, but one, who completed the study decided to continue with the exercises. They were then allocated to a new group and continued recording. These results are yet to be tabulated.

Conclusions – Four important observations:
(1) subjects require follow up supervision to ensure correct execution of the exercises. At the first exercise check, all subjects needed a substantial amount of hands on guidance to perform the exercises with good technique, but, by the second check, of 15 subjects who attended, only one person was not performing the exercises correctly;
(2) during periods of non-practice, correct execution was quickly forgotten. At the final assessment, after two weeks of not practicing the exercises, fourteen of the subjects were unable to reproduce the exercises with their previous level of technique. However, retraining was an easy task as most subjects only needed reminding and minimal supervision; thus
(3) understanding the intent of the exercise was more important for correct execution than other factors, such as the age of the subject; and
(4) because the relaxation posture and the postural training exercise were intended to target psoas, it may point to the importance of psoas in LBP symptoms.

Implications – If the intervention has a positive outcome on the reduction of LBP symptoms and the improvement of pelvic stability, perhaps more attention should be paid to the structure of exercise regimes, include regular follow-up to ensure correct execution and the inclusion of other activities that may impact on exercise.

	Pain Duration Weeks 1-6				Pain Intensity Weeks 1-6			Stork Test
Group	No of days	Shortest	Longest	Average	Short	Long	AV	Wt bearing
A	↓	↓	–	–	↓	↓	↓	↑
B	↓	↓↓	–	–	↓↓	↓↓	↓↓	↑↑
C	↓	↓↓↓	–	–	↓↓↓	↓↓↓	↓↓↓	↑↑↑

Table 1

Key Words – exercise, Pilates, lower back pain, psoas

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Proceedings of the Australian Pilates Method Association National Conference Melbourne 2008

Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

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Aims:

- To determine whether a basic set of Pilates exercises improves the efficiency of load transfer through the pelvis
- To compare the effects on chronic, mild low back pain symptoms of three slightly different Pilates based regimes

Study design:

- Between subjects equivalent group experiment
  - Independent variable: type of exercise training (three groups)
  - Dependent variables: efficient load transfer through the pelvis as measured by the Stork test in weight bearing; low back pain symptoms

Methods:

- Thirty nine volunteers with mild chronic low back pain (LBP) were taught four Pilates based exercises before being randomly allocated to one of three groups for the addition of other interventions.
- Exercises were performed three times per week for six weeks
- Recording was done once per week for eight weeks
- For each of the eight weeks, subjects recorded frequency, intensity and duration of back pain

Groups:

- Groups A, B and C received four basic exercises before being randomly assigned to a group
- Groups B and C received an additional relaxation posture using a specific spinal support
- Group C received an additional postural training exercise eccentrically loading the psoas muscle

Final Assessment Data Collection:

- Complete Oswestry Disability Questionnaire
- Record Stork test
- Return of recording sheets
- Exercise check

Results:

Oswestry Disability Questionnaire

- Question 1 - *Do you have back pain at present?* - was the only question where there was a significant change from baseline and subjects reported a reduction in pain
- Group B experienced a greater reduction in pain than groups A and C, but it was not significant

Number of Days of Pain

- There were no significant differences between the groups, but there were significant differences

within the groups across the weeks of exercising ($F_{7,14}$=10.1, p<0.0001)
- Groups B and C experienced a greater reduction in the number of days of pain than group A
- Some of the improvements were lost once exercising ceased at the end of week 6

Duration of Back Pain Episodes
- All groups experienced a reduction in the mean length of the shortest, longest and average pain episodes
- At week eight all groups had subjects who were pain free (Group A: 7.7%, Group B: 30.8%, Group C: 25%) and in Group B, no subjects reported pain episodes longer than six hours
- There were no significant differences between the groups
- Some of the improvements were lost once exercising ceased at the end of week 6

Intensity of Pain Across All Lengths of Pain Episodes
- All groups experienced a reduction in the intensity of pain across all lengths of pain episodes. However, Group A failed to experience a further reduction in intensity of pain after week four, while Groups B and C continued to experience a further reduction in pain through to week six
- The only statistically significant inter group difference involved Group A and Group B on the shortest pain episodes at Week 6, with Group B experiencing a greater reduction in pain intensity than Group A (Kruskal Wallis, p=0.02)
- And for all groups, intensity of pain tended to rise once exercising ceased

Stork Test in Weight Bearing
- Initial results (n = 22) pointed to a significant improvement, however, this was not reflected subsequently (n = 39)
  - This could have been because total subject numbers were small
  - It is unlikely to reflect changes in measurement method or interpretation, as all tests were carried out by the same person,
- This unexpected result led to an examination of the stance for the starting position for the stork test

Procedure
- Stork tests were carried out by a physiotherapist experienced in taking Stork tests who was not aware of the purpose of the test
- Ten subjects
- Three different standing positions to commence the test
- Neither subjects nor standing positions were tested consecutively
  - Not one subject had the same result recorded from all three positions
  - There was no pattern to the results observed
  - Two subjects had different results recorded from all three positions

Observations
- For correct execution of the exercises:
  - Subjects required follow up supervision
  - Those who had more individual attention learnt faster than those who had less
  - Understanding the intent of the exercise was more important than other factors such as age

- During periods of nonpractice correct execution was quickly forgotten

- Good acceptance of the program - 95% of the subjects decided to continue
  - However, compliance became an issue – the fewer the LBP symptoms, the less likely the subjects were to comply

Conclusions

- Current pain symptoms (Oswestry Disability Questionnaire) showed a reduction in pain
- All groups experienced statistically significant reductions in the frequency, duration and intensity of pain across the weeks of exercising
- Effects were not statistically significant between the groups, except for one instance
- Results indicate that other factors such as postural training and relaxation may impact on exercise programs
- As the psoas muscle was the intended target for relaxation and training, it may indicate its importance in exercise rehabilitation
- Consistency of practice, supervision and follow up are important for correct exercise execution
- Once exercising ceases, reductions in LBP symptoms tend to diminish
- Stork test results suggest that further investigation of the testing process may be necessary

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Title: Altered Motor Control, Posture and the Pilates Method of Exercise Prescription

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ABSTRACT

Summary: The objectives of this study were to compare the effects of three different Pilates regimes on chronic, mild low back pain symptoms and to determine whether the efficiency of load transfer through the pelvis is improved by those exercises.

A between subjects equivalent group experimental design was used. The independent variable was the type of exercise training (three groups) and the two dependent variables were low back pain symptoms and load transfer through the pelvis.

The outcome measures of the first dependent variable were a comparison between modified Oswestry Disability Questionnaires (one of the standard pain instruments) completed pre and post program and frequency, intensity and duration of low back pain.

The outcome measure of the second dependent variable, efficiency of load transfer through the pelvis was the Stork test (One Legged Standing test) in weight bearing.

Although all groups experienced statistically significant reductions in frequency, intensity and duration of low back pain across the weeks of exercising, there were no significant differences between the groups relative to each other.

ALTERED MOTOR CONTROL, POSTURE AND THE PILATES METHOD OF EXERCISE PRESCRIPTION

Relevance and Purpose

Although Pilates has had a major effect on the exercise industry, there is little direct evidence for its efficacy. The purpose of this project was to determine whether a basic set of Pilates exercises improves the efficiency of load transfer through the pelvis and to compare the effects on chronic, mild low back pain (LBP) symptoms of three different Pilates regimes.

As many studies have been undertaken where exercise has been compared to no exercise in the treatment of chronic LBP and results usually favour exercise, all subjects received exercises. Only four exercises were used for the basic program because in exercise-based studies that incorporate large numbers of exercises it is difficult to tell which exercises are effective.

Study Design

The study was a between subjects equivalent group experiment with the independent variable being the type of exercise training (three groups) and the dependent variables being efficient load transfer as measured by the Stork test (One Legged Standing test) in weight bearing (Hungerford et al, 2004) and LBP symptoms. (see Figure 1)

Figure 1: Stork test in weight bearing

<u>Methods</u>

Thirty nine volunteers with mild chronic LBP were first taught a basic set of Pilates exercises then randomly divided into three groups for the addition of other interventions.

At entry, to establish baseline values, subjects completed an Oswestry Disability Questionnaire (Victorian Workcover Authority, 2004) and recorded the frequency, intensity and duration of their back pain in an average week. Also, a Stork test was recorded.

Subjects were taught four basic exercises before being randomly allocated to a specific intervention group (A, B or C).

Two of the exercises were performed supine and involved abdominal muscle contraction and a small degree of trunk flexion. (see Figures 2 and 3)

One exercise was performed side lying and involved trunk muscle contraction, but no side flexion. (see Figure 4)

One exercise was performed prone and involved spinal extensor muscle contraction and a small degree of spine extension. (see Figure 5)

Figure 2: Abdominal curl focused on thoracic flexion and was the first exercise of the four basic exercises in the program for all groups

Figure 3: Oblique abdominal curl focused on thoracic flexion at an oblique angle and was the fourth exercise of the four basic exercises in the program for all groups

Figure 4: Double leg lift focused on maintaining static trunk stability as the legs were lifted just off the floor and was the second exercise of the four basic exercises in the program for all groups

Figure 5: Spine extension focused on thoracic extension with lumbar stability and was the third exercise of the four basic exercises in the program for all groups

Group A received no additional exercises.

Groups B and C received a relaxation posture on a specifically designed spinal support to use before the basic exercises. (see Figure 6)

Group C also received a postural training exercise involving hip flexion and eccentric psoas contraction to be performed after the basic exercises. (see Figure 7)

Figure 6: The relaxation posture was maintained for 3-5 minutes by groups B and C before commencing the basic exercise program

Figure 7: Genie focused on maintaining a neutral spine, while hinging backwards from the hips and was the final exercise for Group C

Each exercise in the basic program was performed with 40 repetitions and the postural training exercise was performed with 20 repetitions. The relaxation posture was maintained for three to five minutes. Exercises were performed at home three times per week for six weeks. Subjects returned for follow up exercise checks, in Weeks 2 and 4.

For eight weeks, subjects recorded the number of days when they experienced back pain in the previous week and whether they had participated in any activities that usually preceded LBP. Using 10-point Semantic Differential scales, they recorded the intensity and duration of the previous week's pain for the shortest, longest and average episodes.

After eight weeks, subjects received a final assessment where they filled out another Oswestry Disability Questionnaire and were asked whether they had changed their normal exercise routine or received other interventions for LBP. A second Stork Test was performed and their exercises were checked again. (see Figure 8)

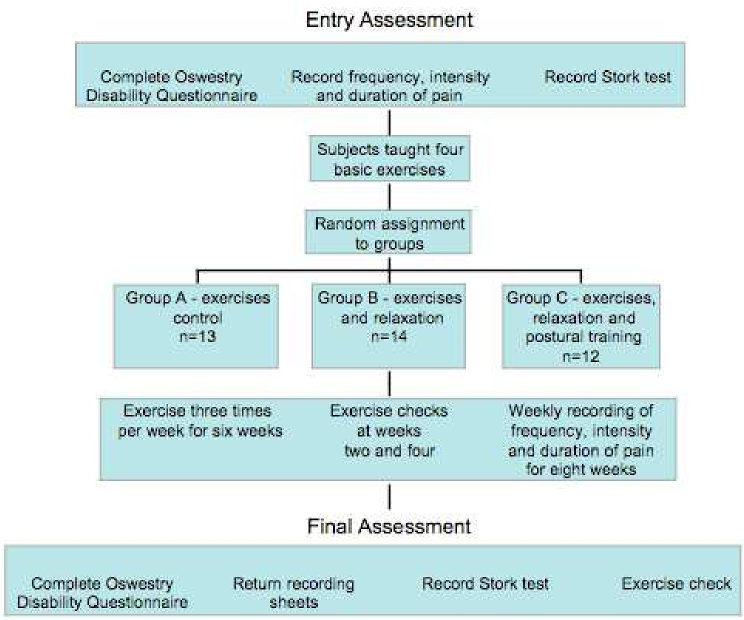

Figure 8: Entry to exit procedure – the flowchart illustrates the process from initial assessment to final assessment for subjects

Results

Oswestry Disability Questionnaire

Pre and post comparison of answers showed only one statistically significant improvement among subject groups. This was for question one, '*Do you have back pain at present?*' where Group B reported significantly less pain post program compared with pre program (Wilcoxon, z=-2.496, p=0.013). (see Figure 9)

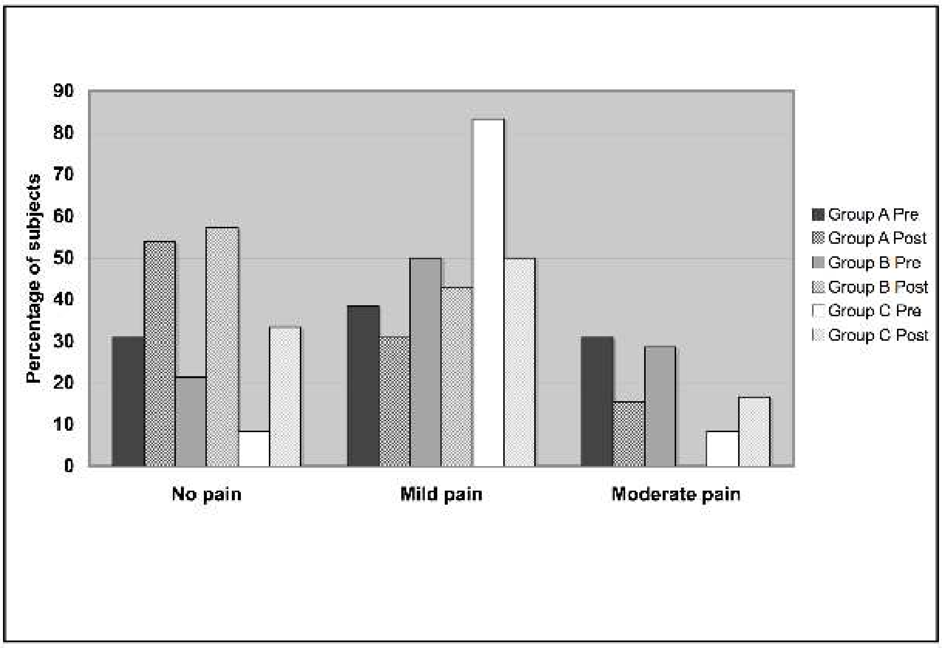

Figure 9: Oswestry Disability Questionnaire – question 1: *do you have back pain at present?* This was the only question where there was a significant change from baseline and subjects reported a reduction in pain. Post-program, although Groups B and C had a higher proportion of subjects with zero pain than Group A and Group B had no subjects with moderate pain, these effects were not significant between groups

Frequency of Pain

Group B experienced a statistically significant reduction in the number of days of pain between Week 1 and Weeks 6 to 8 ($F_{7,84}$=6.4, p=0.0001). Post hoc analysis using Scheffé showed significant differences between Week 1 and Weeks 6, 7 and 8 and between Week 2 and Week 8 ($p<0.05$). There were statistically significant differences by week within Group C

($F_{7,77}$=3.29, p=0.0041), but they only show up with Fisher ($p<0.05$) and they were between Week 1 and Weeks 6, 7 and 8, Week 2 and Weeks 6, 7 and 8, Week 3 and Weeks 6 and 7 and between Week 4 and Week 7.

Some of the improvements were lost once exercising ceased at the end of Week 6. (see Figure 10)

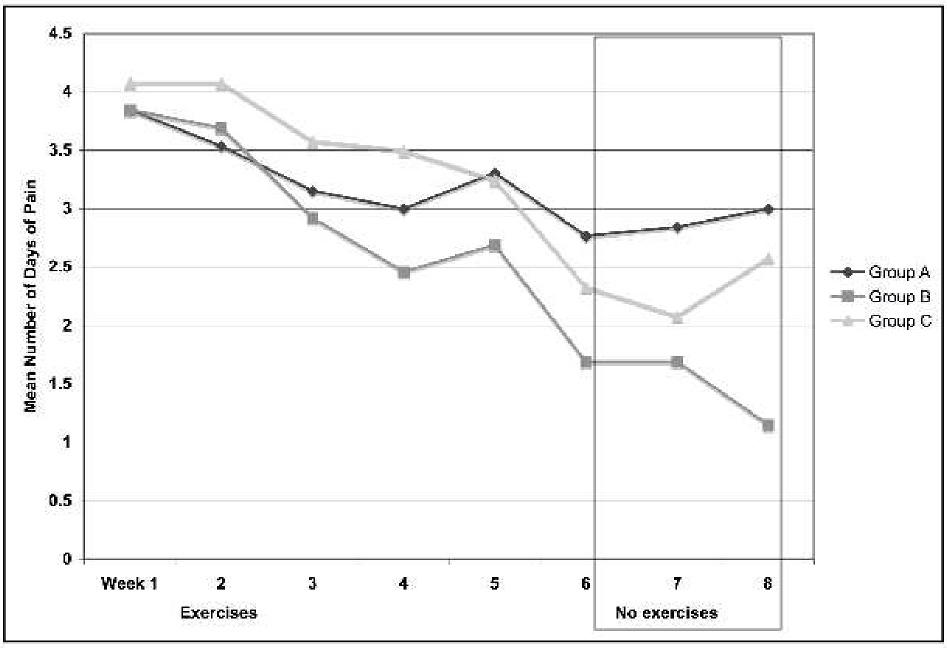

Figure 10: Frequency of pain – although Groups B and C experienced a greater reduction in the number of days of pain each week than Group A, this effect was not significant between the groups

Duration of Back Pain Episodes

As the study progressed, all groups experienced a reduction in the mean length of the short, long and average pain episodes and at Week 8 all groups included some subjects who were pain free. While the proportions of pain free subjects in Groups B and C (30.8% and 25% respectively) were higher than for Group A (7.7%), differences were not statistically significant for the duration of this study.

Some of the improvements were lost once exercising ceased at the end of Week 6. (see Figure 11)

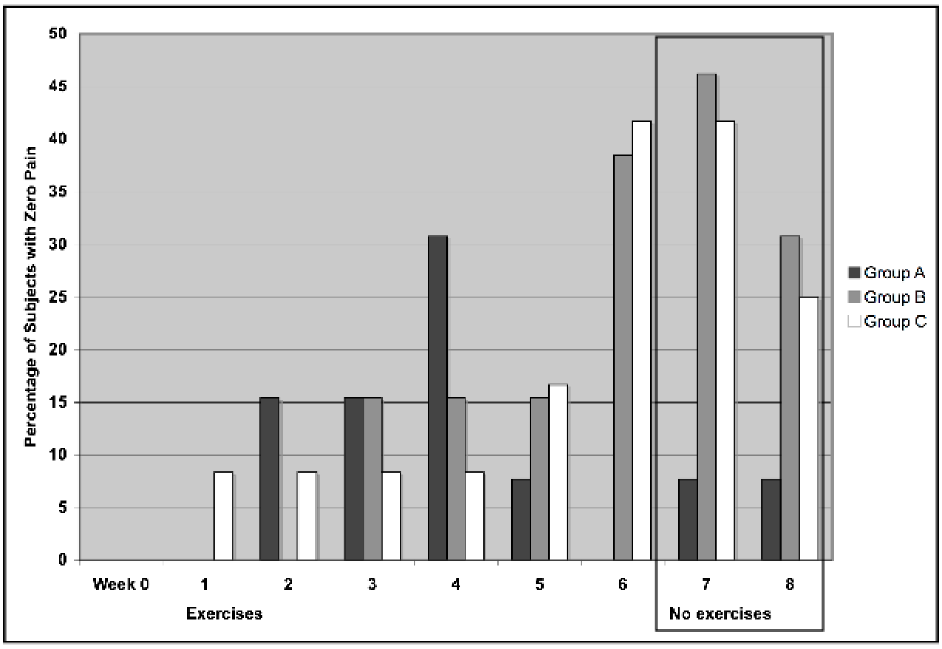

Figure 11: Duration of pain – on the average length of pain episodes, although Groups B and C had a higher proportion of pain free subjects by Week 6 than Group A, this effect was not significant between groups

Intensity of Pain

While all groups experienced a reduction in the mean intensity of pain across all lengths of pain episodes, the only statistically significant inter group difference involved Group A and Group B on the shortest pain episodes at Week 6, with Group B experiencing a greater reduction in pain intensity than Group A (Kruskal Wallis, H=7.83, p=0.02) (see Figure 12)

However, for all groups, intensity of pain tended to rise once exercising ceased. (see Figure 13)

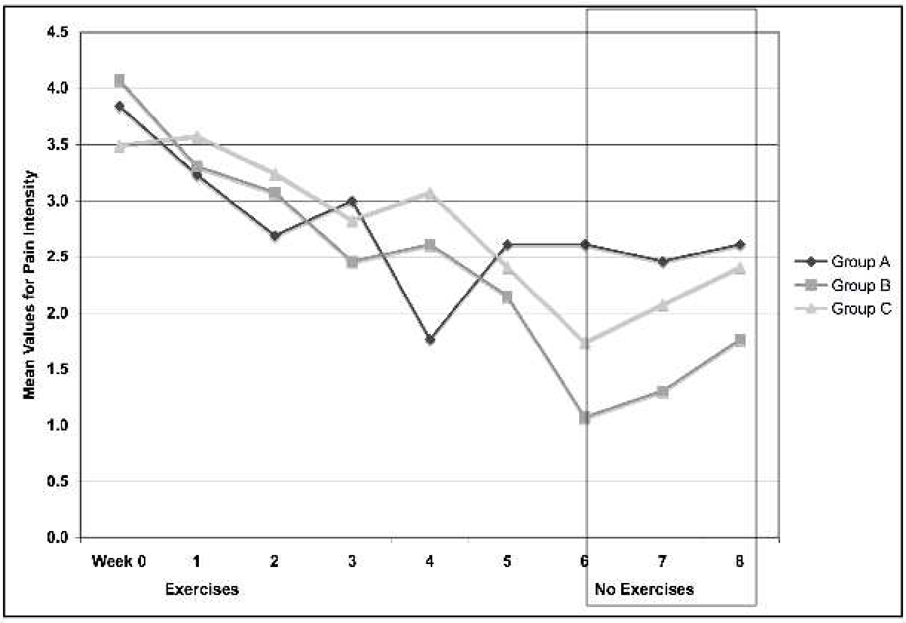

Figure 12: Intensity of pain on the short length of pain episodes

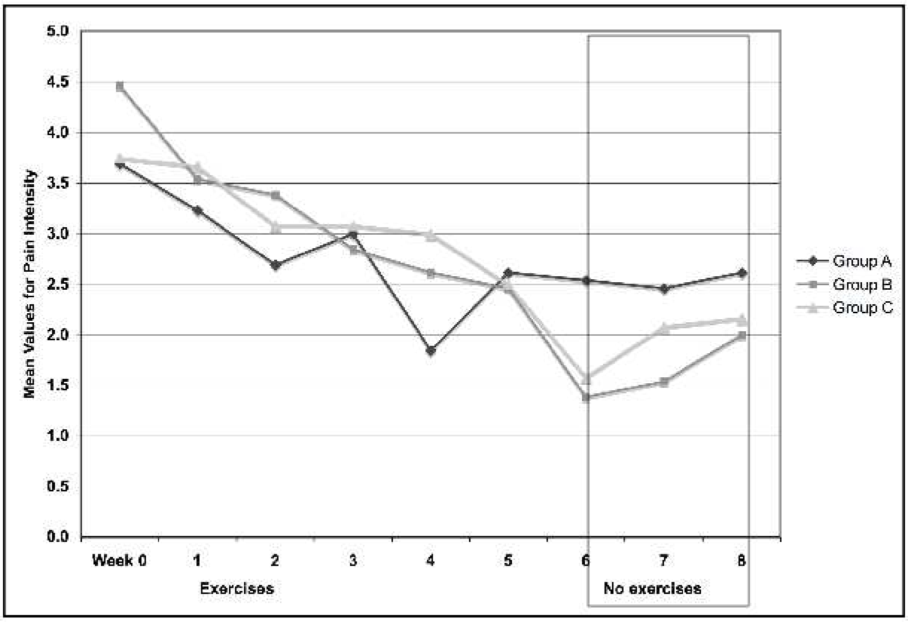

Figure 13: Intensity of pain on the average length of pain episodes – there were significant differences across the weeks of exercising with Group A experiencing a reduction in the intensity of pain till Week 4, and Groups B and C continuing to experience a further reduction through to Week 6. However, the difference between the groups was not significant.

Stork Test (One Legged Standing Test) in Weight Bearing

Although the preliminary results for the Stork test that involved only the first 22 subjects completing the program showed a significant improvement for Group B (Wilcoxon, z=-2.121, p=0.034), this was not the case when data for all 39 subjects were analysed. Although the groups were randomly distributed, the initial data analysis might have reflected the small numbers at that stage, n=22, and not reflected the actual distribution of individuals in the total groups when n=39. It is unlikely that it reflected changes in the measurement method or interpretation, since the same person carried out all tests. Therefore, this unexpected result led to an examination of one aspect of the testing procedure that related to the 'subject', i.e. the starting position for the stork test.

Ten subjects were given three different standing positions for the commencement of the Stork test, normal stance (a), feet close together (b) and feet shoulder width apart (c). Tests were carried out by a physiotherapist experienced in taking Stork tests who was blinded i.e. not aware of the purpose of the test. Neither subjects nor starting positions were tested consecutively.

Not one subject had the same result recorded from all three positions and there was no pattern to the results observed. Furthermore, two subjects had a different result recorded in each of the three positions. (see Figure 14) Because the distance between the feet in the standing position for the commencement of the test yielded variable results, the test may not be a reliable comparative measure pre to post treatment, unless the starting position is standardised. These results indicate that further investigation with a larger sample may be warranted.

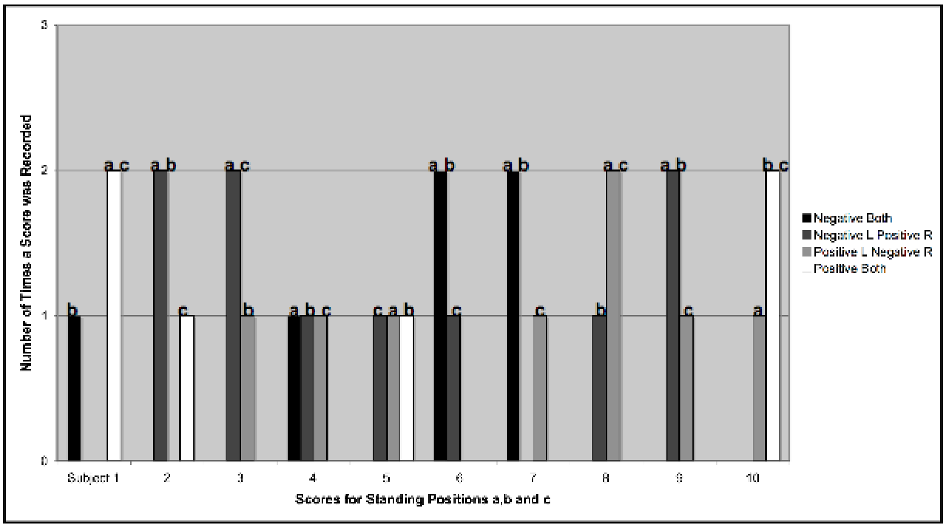

Figure 14: Stork test results – the three standing position for the commencement of the test were: normal stance (a), standing with feet close together (b), standing with feet shoulder width apart (c). The text on the columns indicates from which position the test was taken. There were four possible results for Stork tests taken from both feet and the shade of the column indicates the result. The y-axis indicates the number of times a particular result was observed

Observations

It was clear that typically, subjects required follow up supervision to ensure correct execution of the exercises and during periods of nonpractice correct execution was quickly forgotten. At the first exercise check at Week 2, all subjects needed correction, but at the second check at Week 4, most demonstrated proficiency. However, at the final assessment, after two weeks of not doing exercises, fewer than half the subjects performed the exercises correctly.

Those who had more individual attention learnt correct execution faster than those who had less. However, understanding the intent of the exercise was more important for correct execution than other factors such as age.

Although there were a large number of repetitions that were time consuming and eventually became boring, the program was well received. Ninety five percent of the subjects decided to continue with the program and were allocated to another group, (for example, if the subject was in Group A, the subject moved to Group B).

Conclusions

All groups experienced a reduction in the mean number of days of pain, duration and intensity of pain each week. These effects were statistically significant within the groups across the weeks of exercising, but not between groups for the duration of this study. Subtle differences in efficacy between the three programs may not have been statistically significantly identifiable as sample sizes were small and length of exercise time was short (six weeks).

Since Groups B and C experienced a greater reduction in symptoms than Group A, this may indicate that other factors such as relaxation and postural training impact on exercise programs. As the psoas muscle was the intended target for relaxation and training, it may also indicate its importance in exercise rehabilitation.

Consistency of practice, supervision and follow up are important for correct exercise execution and once exercising ceases, reductions in LBP symptoms tend to diminish.

Stork test results suggest that further investigation of the testing process may be indicated.

Problems

The major problem with the project was the small number of subjects, which contributed to low statistical power.

Although 95% of the cohort decided to continue with the program and were assigned to different groups, compliance became an issue with the second eight week round. Many subjects forgot to do their exercises consistently and it was noted that the fewer the LBP symptoms, the less likely subjects were to comply.

Acknowledgement

We would like to thank Danielle Garrett for modelling for the Stork test and exercise photographs.

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