School of Physiotherapy

Assessing the Efficacy of a Specific Physiotherapy Intervention for the Prevention of Low Back Pain in Female Adolescent Rowers: A Field Study

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Declaration

To the best of my knowledge and beliefs the information contained in this thesis does not contain material previously published by another person except where acknowledgement to those authors is made.

The material presented in this thesis has not been accepted for any other award of degree or diploma at any other university.

Signature

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Date:

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Abstract

Objectives: To determine the efficacy of a specific physiotherapy intervention administered to adolescent female rowers with the aim to decrease the prevalence of low back pain (LBP) and associated levels of pain and disability. A secondary aim of the study was to determine whether changes in lower limb endurance and flexibility were evident in an experimental group.

Design: A non randomized controlled trial in adolescent female rowers with and without LBP.

Setting: Curtin University of Technology, Western Australia and the participating private school boatshed, Perth, Western Australia.

Participants: Participants were 82 adolescent female rowers, with and without LBP. These participants attended the same school and were aged between 13 – 17 years [experimental group 13.9(0.9) years, control group 13.8(1.0) years]

Main Outcome Measures: Primary outcome measures in this study included; LBP point prevalence, pain intensity (utilizing a visual analogue scale) and disability level (utilizing a modified Oswestry questionnaire). These measures were taken at four time points over the rowing season. Secondary outcome measures of lower limb flexibility (sit and reach test) and lower limb endurance (timed squat test) were taken in the experimental group only.

Results: The experimental group demonstrated a significant reduction in the prevalence of LBP across the rowing season 48% to 19% pre-season to mid-season and from 48% to 24% pre-season to end-season. The prevalence of LBP in the control group slightly increased from 22% to 25% pre-season to mid-IV season and was unchanged at 22% pre-season to end-season. A significant increase in the proportion of subjects pain-free was shown in the experimental group at mid-season compared with pre-season ($p=0.007$), but no change thereafter ($p>0.05$). In the control group the proportion pain-free remained relatively stable across the four time points ($p>0.2$ for changes between consecutive times). The experimental group rowers demonstrated reduced pain intensity over the course of the rowing season compared with the control group [mean pre-end season exp 6.4(21.0), control -2.7(17.6) Z= -2.283, p = 0.022]. Levels of disability did not differ between the groups across the rowing season. Significant improvements in lower limb endurance and flexibility were observed in the experimental group (p=<0.05).

Conclusions: A specific physiotherapy exercise intervention was effective in reducing the prevalence of LBP in a population of adolescent female rowers and reducing pain intensity levels in subjects who complained of LBP at the commencement of the rowing season. A randomized trial to test the intervention under more rigorous scientific conditions is recommended.

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List of Abbreviations

LBP	Low Back Pain
VAS	Visual Analogue Scale
Osw	Oswestry Disability Questionnaire
IGSSA	Independent Girls' School Sports Association

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Chapter 1

1.1 Introduction

Low back pain (LBP) has been widely reported in the literature as a significant problem in competitive rowing (Howell, 1984; Reid & McNair, 2000; Caldwell, 2003). The possible causes of LBP in rowers are reportedly multi-factorial and have been well documented in the literature (Adams & Dolan, 1995; Reid & McNair, 2000; Caldwell et al, 2003; Burnett et al, 2008). Predisposing factors such as repetitive lumbar flexion, combinations of flexion and rotation, a lack of anterior tilt of the pelvis, deficits in leg and back muscle endurance and a lack of flexibility in the hamstring muscles may all contribute to excessive loading of spinal structures at end range and have been postulated as causative factors in the onset of LBP in rowers (Reid & McNair, 2000; Perich et al, 2006; Burnett et al, 2008).

The reported literature clearly identifies two categories of risk factors in rowing: those risk factors associated with the individual who rows and those risk factors associated with the requirements of the sport of rowing. Individual risk factors associated with the physical characteristics of the individual, such as limitations in flexibility of the hamstrings, deficits in leg and back muscle endurance, deficits in motor control resulting in increased flexion strain and habitual sitting postures such as slump sitting may predispose the rower to experience LBP (Adams and Dolan, 1995; Reid and McNair, 2000; Roy et al., 1990; Caldwell et al, 2003, Perich et al, 2006). More general risk factors associated with the sport of rowing such as repetitive flexion and combinations of rotation with flexion along with high training and competition loads, may also render the rower more prone to LBP (Adams and Dolan, 1995; Reid and McNair, 2000; Caldwell et al, 2003; Burnett et al, 2008). A combination of both individual and sport specific factors may increase the magnitude of risk of LBP.

In contrast, there are few prevention programs that have been documented for rowers with LBP. One recent study by Perich et al (2009) is the first study investigating and evaluating the effectiveness of a multi-dimensional intervention program. This program consisted of musculoskeletal screening conducted by a physiotherapist where so called "specific exercises" were prescribed. In addition, off-water strength and conditioning sessions and rower education were also conducted. Generally speaking, there is a paucity of literature for specific exercise interventions for the management of LBP across all sporting populations. The documented exercise interventions in sporting populations are largely generic exercise programs delivered in group settings with limited efficacy (Cusi et al, 2001; Nadler et al, 2002; Tse et al, 2005; Harringe et al, 2007).

The aim of this thesis was to examine the efficacy of the specific physiotherapy component of the intervention program (previously reported by Perich et al, 2009), to decrease the prevalence of LBP and associated levels of pain and disability. A secondary aim of the study was to determine whether changes in secondary outcome variables (lower limb endurance and flexibility) were evident in the intervention group.

1.2 School Rowing Program in Perth, Western Australia

Rowing is one of the largest participant sports on the Independent Girls' Schools Sports Association (IGSSA) calendar. Each year in Western Australia approximately 400 girls aged 13 years and above (year 9 to year 12) from six private girls' schools participate in a number of interschool regattas over the winter months, from March to August, which culminate in the prestigious Head of the River competition in August. Some schools encourage rowing at an even younger age (year 8, aged 12 and 13 years).

Rivalry between schools is fierce and a significant amount of time, money, fundraising and energy is devoted by the schools, girls, parents and coaching staff to perform well throughout the rowing season. Girls selected to be rowers in the first eight crews for the 'Head of the River' regatta are rewarded with respect and notoriety within their school community. As a result, the competition between girls within each school for selection is intense, as well as there being strong competition between coaches and schools. Publicity associated with victory in the Head of the River regatta receives significant media coverage in the newspapers and television as well as the school communities. Therefore, success both in the first and second eight crews at the Head of the River is extremely important to the independent girls' schools involved.

Concern was noted within IGSSA at the increasing numbers of girls who were reporting LBP associated with rowing, in particular sweep eight rowing which constituted the premier events in the Head of the River competition. Until 2005, this information was largely anecdotal and there was little evidence on which to base these claims. In fact, a number of schools were seriously considering removing rowing altogether from their curriculum due to concerns at the large number of anecdotal reports of LBP. Further, other schools were reportedly considering dropping the sweep rowing component of their programs and only participating in scull rowing. This however, would have a major impact on the future of the Head of the River competition where the premier event is the sweep eights. Subsequently, IGSSA recognised the need to investigate the problem further.

1.3 Study background

During 2005, Ms Debra Perich, a physical education teaching and rowing coordinator at Perth College (an independent girls' school involved in rowing) received funding from IGSSA and from Perth College to further explore the concerning issue of LBP in this population of adolescent girls. This research became a doctoral thesis comprising two separate studies (Perich et al, 2006, 2009). The first part of the initial study (Perich et al, 2006) examined the prevalence of LBP in schoolgirl rowers across all IGSSA schools offering rowing as a sport. This study consisted of approximately 400 girls and results of this study were concerning, identifying LBP as being common in adolescent female rowers. The point prevalence of LBP was 47.5% for the adolescent female rowers across the schools as compared with 15.5% in an age-matched control group. The second part of the initial study (Perich et al, 2006) investigated differences in physical and psycho-social factors in schoolgirl rowers with and without LBP. Significant differences were found between the LBP and no LBP groups with regards to lower limb endurance and back muscle endurance, suggesting premature fatigue of the legs may result in increased load being transferred to the rowers' lower back. In addition, a difference was identified in the pelvic tilt angle between usual and slump sitting, indicating girls with LBP are sitting in a more slumped position in their usual sitting position than their counterparts without LBP. There were no significant differences evident between the LBP and no LBP groups for psycho-social variables or beliefs about LBP.

The second study consisted of an intervention study undertaken to prevent low back pain in adolescent school girl rowers (Perich et al, 2009). This was a multi-dimensional intervention study conducted during the 2006 rowing season. In this non randomised controlled trial one IGSSA school, Perth College, consisting of 90 schoolgirl rowers between the ages of 14-17 years, formed an experimental group. A control group consisted of 131 other schoolgirl rowers, aged 14-17 years, from three other IGSSA schools. The hypotheses of this study was that a multi-disciplinary intervention, which included an individually tailored exercise program, would reduce the incidence of LBP in adolescent schoolgirl rowers across the rowing season, and would also decrease the level of pain and disability for those with existing LBP.

This multi-dimensional intervention program comprised an education session, physiotherapy musculoskeletal screenings by a team of experienced physiotherapists, individually prescribed exercise intervention programs based on the findings of the musculoskeletal assessment, physical conditioning program and reduced time spent on water training with increased land training The individually prescribed exercise program was designed to change sitting, lifting and rowing spinal postures with progressive conditioning of the lower limbs and back muscles in these corrected postures. The aim was to reduce sustained flexion spinal loading of the lumbar spine.

The first aspect of the musculoskeletal screening involved an interview to assess current and previous history of LBP, pain location, aggravating and easing factors for LBP, as well as treatment history, attitudes towards LBP, current levels of rowing training and general activity. Following this, a musculoskeletal physical examination was carried out in order to examine spinal range of movement, directional pain provocation, habitual spinal postures in sitting and standing and spinal proprioception. Lumbo-pelvic motor control was assessed by the ability to maintain a neutral lumbar spine with a relaxed thorax in sitting; whilst performing active hip flexion and knee extension; sitting bending with forward reach; sit to stand; squat; squat with forward reach; and the row position. Lower limb endurance was measured with a timed squat test (maintaining a neutral lumbar spine posture while in a squat position with 90^{o} flexion at the hips and knees). Lower limb flexibility was measured with the sit and reach test. The ability to maintain a neutral lumbar spine during rowing and the ability to control end range lumbar flexion postures was assessed visually on the rowing ergometer.

The results of the Perich et al (2009) study demonstrated that the experimental group receiving the multidisciplinary intervention had a significantly lower prevalence of LBP (26%) across the rowing season when compared with the control group (46%). Physical conditioning significantly improved in the experimental group as did the measures of back muscle endurance (Beiring-Sorenson, 1984) and lower limb endurance (timed squat test). The girls also sat more upright and significantly further from end range lumbar flexion and sat with a more anterior pelvic tilt when in their usual sitting posture.

Although successful, the intervention had a number of potential confounding factors such as a lack of consistency between the intervention school and the control schools with regards to education, rowing/ergometer training programs, coaching input, physical conditioning sessions and time spent on water training versus land training. As a consequence of these factors not being controlled for, due to the nature of the field based study, it was unclear as to the specific effect the physiotherapy component of the intervention had on reducing LBP prevalence in the girls.

Following the significant benefits reported by Perth College in reducing LBP incidence following the multi-dimensional intervention program in 2006, IGSSA requested the physiotherapy intervention be made available to all schools offering rowing as a sport within their curriculum. A number of schools displayed interest in implementing the program at the commencement of the 2007 rowing season.

An alternate IGSSA school committed to address the issue of LBP in their school and requested the implementation of the physiotherapy intervention as part of their rowing program for 2007. This was recognised as an opportunity to implement the physiotherapy intervention in the one school while better controlling for factors such as education, coaching input, physical conditioning and training schedules. In this manner, the efficacy of the physiotherapy component was better able to be assessed whilst controlling for these factors and thus formed the basis for the development of this Masters thesis to be undertaken.

1.4 Low Back Pain in Children

LBP, defined as pain or ache in the lumbosacral region with or without radiation to the buttocks (McGregor et al, 2002) is a concern in children. Balague et al (2003) investigated a large population of children (n=1496) and documented a high prevalence of LBP (up to 34% in girls aged 14 years and over). Only 24% of these children had sought medical intervention or advice for their LBP. It is known that LBP prevalence increases with age and is more common in females with a strong familial association (Balague et al, 1999). Onset of LBP in adolescence is considered to be a risk factor for LBP in later life (Burton et al, 1996).

Underlying mechanisms for the high prevalence of LBP in adolescence may relate to biopsychosocial factors, developmental, educational or cultural issues (Balague et al, 2003). Balague et al (1999) suggested that high prevalence rates of LBP in children may be related to family history and heredity, psycho-social issues, anthropometric parameters (height, weight and body mass index), spinal mobility and flexibility of muscles and joints, spinal posture, muscle strength and levels of participation in physical and sporting activities.

Taking into consideration the reported risk factors associated with LBP in children and adolescents in the general population, these risk factors have the potential to be amplified in a population of adolescent females who participate in the sport of rowing. A recent study of adolescent female rowers by Perich et al (2006), demonstrated a LBP point prevalence rate (taken at four time points over the rowing season) of 47.5% when compared with 15.5% in equally active non-rowers (Perich et al, 2006). These findings are supported by other research involving rowers of all ages and abilities

(Howell, 1984; Perich et al, 2006; Stutchfield & Coleman, 2006), suggesting prevalence rates may be higher in adolescents who row.

In the previous study reported by Perich et al (2006), the factors associated with LBP in a group of adolescent female rowers were: reduced lower limb endurance; reduced back muscle endurance; differences in pelvic tilt in different sitting postures. Perich et al (2006) did not find an association with psycho-social issues in their population of rowers, suggesting that physical and mechanical risk factors were the predominant findings for LBP in rowing. This is not entirely consistent with the findings of Balague et al (1999) who demonstrated an increased LBP prevalence in association with psycho-social factors. These findings may reflect the presence of different risk groups for LBP in the adolescent population which may be dependent on participation in a specific sport.

1.5 The Sport of Rowing

Participation in the sport of rowing has steadily increased in recent decades (Rumball et al, 2005). Rowing is divided into two categories: sweep rowing (the use of one oar per rower with rowing on one side of the boat) and scull rowing (the use of two oars rowing on both sides of the boat). Sweep boats are pairs, four and eight. The eight always have a coxswain. Sculling boats are single, double and quad, with all sculling boats being coxless (Rumball et al, 2005).

Each rower is assigned to a seat in the rowing shell which slides back and forth on tracks. The foot stops are attached to a plate that is positioned at various angles for effective leg drive. The oar is held in an oar lock. The rowing stroke includes the catch, drive, release and recovery (Rumball et al, 2005).

1.6 Injuries Associated with the Sport of Rowing

The most frequently injured area in rowers is the lower back, purported to be due to repeated and loaded lumbar spine flexion and twisting (Rumball et al, 2005), however the literature would suggest possible causative factors to be multifactorial as previously discussed. Rib stress fractures account for the most time lost from rowing training and competition (Rumball et al, 2005). Other injuries associated with the upper limbs, shoulder pain, forearm and wrist symptoms are also reported. Lower limb injuries associated with patellofemoral pain or iliotibial band friction syndrome have also been documented (Rumball et al, 2005). The risk factors associated with injury in rowing appear to be primarily associated with the sport of rowing or the individual physical characteristics of the rower.

1.6.1 Sports specific risk factors for LBP in rowing.

(i) excessive flexion/ rotation

Rowing is a sport that involves repeated flexion loading of the lumbar spine. During the rowing stroke, loaded lumbar flexion at the catch whilst in a seated position has the potential to load passive spinal structures, potentially increasing the risk of injury to these structures. Hyperflexion is exacerbated at the catch position, as the lower back muscles are relatively relaxed and then great loads are placed on the spine as the blade drives through the water (Rumball et al, 2005). High compressive loads have been reported in men and women during the rowing stroke (Reid & McNair, 2000). The combination of flexion with compressive loading has been identified as a potential mechanism of injury to lumbar spine structures (Adams & Dolan, 1995; Reid & McNair, 2000). This is supported in a study of adolescent male and female high school rowers by Caldwell et al (2003) who showed high levels of lumbar flexion were attained during the rowing stroke and these increased during the course of an ergometer rowing trial.

There is increased risk of tissue strain at end range of spinal motion where the passive spinal structures are maximally loaded (Panjabi, 1992).

In addition to flexion and compression, sweep rowers also rotate their spine. The addition of rotation to a spinal segment that is at its end range flexion may result in increased tissue loading of passive spinal structures (bone, ligament and disc) as there is less compliance to movement at the end range of flexion (Burnett et al, 2008). Conversely, when the spine is rotated or loaded within a more neutral position of a motion segment, there is more compliance within the passive spinal structures thereby potentially reducing the risk of injury to these structures (Panjabi, 1992; Burnett et al, 2008). Reid and McNair (2000) suggest repetitive strain may also lead to de-sensitization of the mechanoreceptors in spinal ligaments. Mechanoreceptors are peripheral afferent sensory neurons present within muscle, tendon, fascia, joint capsule, ligaments and skin about a joint (Myers et al, 2006) which can be pain sensitive under stress. These receptors often have pathways that lead to reflex activation of the back muscles, which may be compromised after prolonged repetitive motion such as rowing (Solomonow et al, 2008)

Sports which combine rotation with spine flexion and extension (eg. fast bowling in cricket) are known to carry greater risk of LBP (Ranson et al, 2008). Burnett et al (2008) describe rowing as one of a number of sports in which high levels of mechanical loading in association with coupled flexion/extension and axial rotation of the lumbar spine are undertaken together with medium to high levels of training and competition. This is supported by Adams and Dolan (1995) who have shown that the addition of axial rotation along with flexion and moderate compressive forces can place considerably more stress upon passive stabilizing structures such as capsule, ligaments and discs. Perich et al (2006) added further credence to this view with reports that in sweep rowers, 64% of subjects reported onset or exacerbation of LBP as compared with single scull (14%) and quadruple scull (37%).

(ii) repeated loading / over loading of the lumbar spine leading to fatigue

The repetitive cyclic action of rowing may predispose the rower to lower back injury (Caldwell et al, 2003). These authors suggest that in a single session a rower may train for 90 minutes during which they may perform 1800 cycles of lumbar flexion. During the rowing stroke the magnitude of the forces on the lumbar spine is high. For example, the average compressive loads on the lumbar spine are 3919N for men and 3330N for women, while anterior shear forces have been found to be 848N for men and 717N for women respectively (Reid and McNair, 2000). These authors also report that rowers are in a flexed posture for approximately 70% of the stroke cycle. This is supported in the recent study by Ng et al (2008b) who showed that rowers with LBP posture their lumbar spine in flexion for a greater proportion of the drive phase and nearer to their end range of flexion when compared with those without LBP. Lu et al (2008) reported that the incidence of 'cumulative trauma disorder' may be evident in individuals who engage in repetitive or cyclic activity over a prolonged period. These authors suggest that high cyclic load magnitudes, repetitive activity along with insufficient rest may elicit an acute neuromuscular disorder indicative of acute inflammation in ligamentous, capsular or disc structures of the lumbar spine. Supporting this, is the research by Solomonow et al (2008) who reported that cyclic and repetitive sports have been shown to trigger high rates of musculoskeletal disorders when undertaken over long periods. In a study undertaken in felines these authors demonstrated that prolonged cyclic loading may compromise spinal stability in the ensuing 2-3 hours post-loading, thereby increasing the risk of spinal injury (Solomonow et al, 2008).

(iii) high levels of training times and volumes

Other contributing factors creating potential for injury to lumbar spine structures include warming up activities of rowers and the time at which they train during the day. A large volume of rowing is undertaken in the early morning and it has been suggested that the bending stresses are three times greater on the spine in the early morning (Adams and Dolan, 1995; Reid and McNair, 2000). Most training for the IGSSA competition takes place in the early morning when the river is calm and as the IGSSA rowing competition is conducted during the winter months, the added effect of cold winter mornings may contribute to a lack of flexibility (Reid and McNair, 2000; Rumball et al, 2005).

1.6.2 Individual risk factors for LBP in rowing

(i) lack of anterior pelvic rotation

Limitations in anterior pelvic rotation have been identified as a technique fault in male and female novice rowers, which may lead to increased flexion loading of the lumbar spine (Reid and McNair, 2000; McGregor et al, 2007). In order to decrease forces on the lumbar spine it has been postulated that rowers should adopt a less flexed lumbar spine, particularly at the catch phase when the oar is placed in the water (Caldwell et al, 2003). There may be an association between a greater degree of anterior rotation of the pelvis at the catch and reduced compressive load on the lumbar spine. This may be due to a reduction in the amount of lumbar flexion (Caldwell et al, 2003). These views are supported by the research of Ng et al (2008b) who found that rowers with LBP spent a greater proportion of their rowing stroke in flexion when compared with rowers without LBP during the drive phase.

(ii) reduced hamstring flexibility

Shortened hamstring muscles may limit the ability to achieve anterior tilt of the pelvis and subsequently result in the need to increase ranges of lumbar and thoracic flexion to achieve an adequate rowing stroke reach (Gajdosik, 1994; Reid and McNair, 2000). In addition, limitations in hamstring length may reduce the range of hip flexion available, resulting in the need for greater range of lumbar flexion required during the rowing stroke, however this has not been formally investigated. Studies involving non-rowers have suggested that inflexible hamstring muscles limit anterior pelvic tilt during trunk flexion, thus requiring greater degrees of lumbar flexion (Gajdosik et al, 1994). Contrary to this, a number of studies have failed to illustrate an association between hamstring flexibility and LBP and report that techniques to increase hamstring flexibility may not prevent LBP or be useful in low back rehabilitation in rowers (Howell, 1984; Stutchfield and Coleman, 2006). One explanation for this may be that the hamstring muscles may only influence the lumbar spine when the trunk is maximally flexed and the hamstrings are under tension. Clearly there are multiple factors which may have an influence on the degree of lumbar flexion, such as leg muscle endurance (Perich et al, 2009), back muscle endurance (Roy et al, 1989) and the length of time spent in a flexed posture during the drive phase (Ng et al, 2008b). The effect of shortened hamstring muscles on the prevalence of LBP is not clearly documented in the literature and may benefit from further investigation.

(iii) deficits in back muscle endurance

Previous studies have reported associations with LBP and a lack of back muscle endurance in industrial workers utilizing repetitive flexion in their work (O'Sullivan et al, 2006b) and deficits in back muscle endurance in individuals reporting LBP (Roy et al, 1989). Deficits in back muscle endurance were illustrated in adolescent female rowers with LBP in the previous research by Perich et al (2006). Further, Roy and de Luca (1990) utilised surface EMG measurement to identify deficits in back muscle endurance that were a characteristic of LBP in rowers.

Activation of back muscles, such as lumbar multifidus, is considered to reduce loads on the intervertebral discs via load transition to the zygo-apophyseal joints in the lumbar spine (Goel et al, 1993). O'Sullivan et al (2002) reported a relationship between trunk muscle activity and different sitting postures. They reported that lumbo-pelvic sitting posture (defined as anterior rotation of the pelvis, neutral lumbar lordosis and neutral thoracic kyphosis) results in tonic activity in the transverse portion of internal oblique, superficial lumbar multifidus and in some cases thoracic erector spinae suggesting these muscles have a postural stabilising role. Activation of these muscles is reduced in slump sitting, where it appears the load is transferred from active stabilising muscles to passive spinal structures. Muscle activation of transverse internal oblique and superificial lumbar multifidus is also reduced in thoracic upright sitting. Thoracic upright sitting (defined by increased thoracic lordosis, less lumbar lordosis and less anterior pelvic tilt) results in greater activation of thoracic erector spinae and external oblique with reduced lumbar multifidus and internal oblique activation potentially resulting in higher compressive forces to be exerted on the spine (O'Sullivan et al, 2006a). To date, it is not known whether this same pattern exists during rowing.

Evidence of back muscle fatigue during ergometer rowing was illustrated in a study by Caldwell et al (2003) with fatigue having the potential to contribute to increased levels of lumbar flexion during the rowing stroke. High levels of back muscle strength and endurance would be required to limit the effect of fatigue given that competitive rowing is primarily an endurance sport (McGregor et al, 2002).

(iv) deficits in leg muscle conditioning

The previous study by Perich et al (2006) identified an association between deficits in lower limb endurance and adolescent female rowers with LBP, compared with pain free adolescent female rowers. This was tested by an isometric endurance squat.

Low hamstring to quadriceps ratios have been reported to be associated with increasing incidence and severity of back injury in rowers (Koutedakis et al, 1997). These authors postulated that weak hamstrings may disturb an optimal derotation of the pelvis leading to low back injury. During the recovery phase of rowing, the pelvis rotates about the hip joints to the degree allowed partly by the lumbosacral spine mobility and partly by the elongation of the hamstring muscles.

(v) gender

In a 10 year retrospective study of injuries to elite rowers at the Australian Institute of Sport it was documented that 25% of all injuries reported by male rowers were of lumbar spine origin as compared with 15.2% in females (Hickey et al, 1997). Hosea et al (1989) proposed that increased forces on the lumbar spine may be evident in male rowers thereby accounting for the difference in LBP incidence between males and females. A study by Ng et al (2008a) illustrated that males tend to row with a more 'slouched' thoracic posture in addition to a greater posterior pelvic tilt which may result in increased flexion loading on the spine. Dunk and Callaghan (2005) suggested there may be fundamental differences between female and male normal sitting posture. They demonstrated that males displayed a more flexed lumbar spine and a more posteriorly tilted pelvis compared with females in normal sitting. Despite these gender differences, the significantly high prevalence rates of 47.5% LBP which have been reported in female adolescent rowers in the recent study by Perich et al (2006) are a major concern. In summary, an increased LBP prevalence in males may relate to different patterns of load, training or biomechanical and postural differences known to be present between the genders.

(vi) motor control deficits

Ng et al (2008b) recently reported in a study of 22 rowers with LBP (10 male, 12 female), that during a prolonged ergometer trial, rowers with LBP spent a greater proportion of their rowing stroke in flexion when compared with those without LBP during the drive phase of rowing. Furthermore, rowers with LBP also spent a greater amount of time near full flexion (above 90% full flexion) in the lower lumbar spine when compared with rowers without LBP. Ng et al (2008b) investigated EMG muscle activation data during a rowing ergometer trial and found no significant differences in superficial lumbar multifidus activity at the catch phase or finish phase of rowing, however rowers with LBP demonstrated greater activation of the thoracic erector spinae at the catch phase. These findings support that rowers with LBP are exposed to excessive flexion loading of the spine during rowing.

1.6.3 A combination of sports specific and individual risk factors may magnify risk for LBP in rowing

It is likely that high prevalence rates of LBP reflect that a combination of individual risk factors and sports specific risk factors co-exist in a sport such as rowing. Identification of these risk factors is the first step in taking measures to reduce LBP prevalence in rowers.

1.7 Exercise Interventions in Sporting Populations

LBP in athletic populations is not uncommon and its occurrence has been widely documented (Cusi et al, 2001; Nadler et al, 2002; Perich et al, 2006; Harringe et al, 2007). In spite of this, there are a limited number of studies demonstrating the efficacy of specific exercise interventions for the prevention of LBP in athletic populations. Core strengthening exercises are often introduced into an athlete's exercise program in an attempt to prevent LBP with little evidence base supporting its implementation. Intervention studies have utilised generic programs with mixed outcomes (Cusi et al, 2001; Nadler et al, 2002; Harringe et al, 2007).

Cusi et al (2001) studied the effects of a randomly assigned exercise intervention in two groups of age, height, weight and player position matched rugby players. Measurements of flexibility and back strength were taken pre-season, mid-season and end-season, and injuries were surveyed throughout the season. Subjects were randomly assigned to an intervention group and both intervention and control groups carried out a standard stretching and fitness regime. The intervention group carried out three additional exercises on a fitball twice weekly throughout the season. The intervention group demonstrated a reduction in low back and groin injuries however no statistical significance was observed in measures of flexibility and trunk strength between groups.

Nadler et al (2001) investigated the influence of a core strengthening program on LBP recurrence and hip strength differences in collegiate athletes. Measurements of hip strength were taken over consecutive years in the same group of athletes. The strengthening program was undertaken during the second year and strength differences were measured. The results of this study did not demonstrate any significant difference in LBP occurrence after completion of a core strengthening program instituted by a certified strength and conditioning coach. The program involved strengthening of the abdominals, paraspinal and hip extensor muscles (undertaken 4-5 times per week pre-season and 2-3 times per week during season).

Harringe et al (2007) evaluated specific segmental muscle control exercises directed at the transverse abdominis and multifidus muscles of the lumbar spine in 51 young female gymnasts (aged 11-16 years) with and without LBP, in a controlled group setting. The experimental group who undertook a 12 week specific segmental muscle training program demonstrated a significant reduction of days with LBP and reduced pain intensity compared with gymnasts in the control group. However, there were a number of methodological limitations of this study which included different sample sizes, non-randomisation of subjects, a lack of standardization of training programs and differences in anthropometric data between groups which limits the validity of the findings.

Koutedakis et al (1997) investigated the effects of a specific hamstring strength training program using predominantly free weights, in improving peak torque ratios (knee flexors/knee extensors) and reducing the prevalence of LBP in female rowers. Following the training program, the female rowers showed a significant increase in peak torque ratio (determined by isokinetic testing of knee extensor to knee flexor peak torques) with a parallel significant decrease in missed days training due to LBP. These authors concluded that a 6-8 month hamstring strength training program can contribute to a reduced LBP prevalence. Prior to the training program, LBP prevalence in female rowers was 52%, however no data on LBP prevalence at the conclusion of the training program was reported. The training program specifically for the hamstrings was undertaken in one sub-group of female rowers, with strength testing performed pre-training and post-training 6 – 8 months later. However as there was no control group for comparison in this study it is important to consider that improvements in hamstring strength may also have been demonstrated as a result of conditioning associated with rowing training. This is an area which clearly requires further investigation

In a group of college rowers, Tse et al (2005) investigated the effectiveness of an intervention program aimed at improving the core endurance of the trunk muscles and improving a variety of functional performance tasks (vertical jump, broad jump, shuttle run, 40 metres sprint, overhead medicine ball throw and a rowing ergometer test). Trunk endurance was assessed using abdominal fatigue test, back extension and side flexion bridge tests. Their results demonstrated the males who undertook an 8 week program targeting transverse abdominis and multifidus muscles showed selected improvements in core endurance parameters. However, no improvements were shown in functional performance tasks. Of interest, is the author's suggestion that improvements in core endurance may be influential in preventing and reducing episodes of LBP despite no data being collected to investigate the effects of the core endurance intervention on LBP prevalence in rowers.

To date, only the one study by Perich et al (2009) has tested an individually applied, specific physiotherapy exercise intervention as part of a multi-dimensional intervention in a rowing population, which showed a significant reduction in prevalence of LBP as compared with the control group. The effects of specific physiotherapy interventions on the prevalence of LBP and changes in pain intensity and disability levels with athletes who experience LBP in sporting populations has not been well documented and is an area which requires further research.

In summary, there is a lack of effective interventions reported in the literature that address factors causing LBP in rowers. General intervention strategies involving trunk strengthening are documented for gymnasts (Harringe et al, 2007), college athletes (Nadler et al, 2001), rugby players (Cusi et al, 2001) and rowers (Tse et al, 2005; Koutedakis, 1997) and have shown mixed results as to the effectiveness of reducing LBP prevalence. Perich et al (2009) appears to be the only documented study which implements a successful specific exercise intervention (targeting the identified individual risk factors and/or sports specific risk factors) to assist in the prevention of LBP in female adolescent rowers. However, the limitations in the study design limit the conclusions as to what factors actually resulted in the change in LBP prevalence. The intervention may have changed the individual risk factors associated with sitting and rowing postures, lower leg and back muscle endurance, hamstring flexibility and education and management strategies for LBP. Alternatively, the intervention may have changed factors associated with the sport of rowing such as reduced time spent on the water and on rowing ergometers and increased land based conditioning. In reality, the intervention is likely to have been successful as a result of addressing both these issues.

1.8 Summary

There are a number of factors reported in the literature as being potential contributing factors to the onset of LBP in rowing which include:

1. Sports specific risk factors for LBP in rowing

- excessive flexion / rotation
- repeated loading/overloading of the lumbar spine connective tissue
- high levels of training times and volumes

2. Individual risk factors for LBP in rowing

- lack of anterior pelvic rotation
- reduced hamstring flexibility
- deficits in back muscle endurance
- deficits in lower leg conditioning
- motor control deficits

These factors may combine to increase the magnitude of the risk of LBP prevalence in rowers.

1.9 Basis for Current Research

Consequently, the basis for this research project was to further the research conducted in the previous study (Perich et al., 2009), in order to assess the efficacy of the specific physiotherapy exercise intervention which targets the risk factors associated with the individual physical characteristics of the rower. In the current study, education and coaching input in the prevention of LBP in female adolescent rowers was better controlled. It is recognised that different coaches within the one school may have differing training methods, however, their input is likely to be more consistent within the one school. Risk factors associated with the sport of rowing such as water versus land training, training volumes and loads and ergometer and physical conditioning programs were consistent between groups.

It was hypothesised that an individually applied specific physiotherapy intervention in schoolgirl rowers (with and without LBP) forming the experimental group would be more effective in reducing;

1. the prevalence of LBP (measured at four points during the rowing season)
2. the back pain intensity in subjects with LBP (measured by a Visual Analogue Scale)
3. level of disability in subjects with LBP (measured by the modified Oswestry questionnaire)

when compared with a control group of schoolgirls rowers (with and without LBP).

A secondary hypothesis was that the experimental group would demonstrate an improvement in lower limb flexibility (measured by sit and reach test) and isometric lower leg endurance (measured by a timed squat) at the end of the rowing season.

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Chapter 2 Paper

Assessing the Efficacy of a Specific Physiotherapy Intervention for the Prevention of Low Back Pain in Female Adolescent Rowers: a Field Study.

Submitted to NZ J sports med

2.1 Low Back Pain in Rowing

Low back pain (LBP) in adolescence has been shown to be a significant risk factor for LBP in adulthood, with the strongest predictor of future LBP being a prior history of LBP (Hestbaek et al, 2006). High prevalence rates of LBP (24%) among children and adolescents have been demonstrated in several studies (Balague, 1999, 2003; Hestbaek et al, 2006). Balague et al (1999) found the prevalence of LBP in a general population of children was higher among girls than boys (up to 34% in girls aged 14 years and over)

Participants in particular sports such as rowing have shown a greater disposition to reporting LBP (Burnett et al, 2008). A recent study of adolescent female rowers demonstrated a LBP point prevalence rate (taken at four time points over the rowing season) of 47.5% when compared with 15.5% in equally active non-rowers (Perich et al, 2006). These findings are supported by other research involving rowers of all ages and abilities (Howell, 1984; Perich et al, 2006; Stutchfield & Coleman, 2006). Although it is not clearly known whether adolescent female rowers have an increased predisposition to LBP when compared with adolescent male rowers, given the findings of Perich et al 2009, the prevention and effective management of LBP in adolescent female rowers is a research priority.

Research has shown that *sports specific risk factors* associated with rowing can potentially increase the risk of LBP prevalence (Adams & Dolan, 1995; Reid & McNair, 2000). Sports specific risk factors related to rowing involve combinations of spinal movements such as excessive lumbar flexion, often with the addition of spinal rotation and repeated loading / over loading of the lumbar spine leading to fatigue. High levels of training times and volumes may also represent potential mechanisms for strain to the lumbar spine structures (Reid & McNair, 2000; McGregor et al, 2007). The combination of repetitive flexion with compressive loading can strain ligamentous structures and significantly increase disc loading (Adams & Dolan, 1995; Burnett et al, 2008).

Another aspect that may predispose the lumbar spine to mechanical strain of connective tissue is the *individual risk factors* of the rower. Individual risk factors such as habitual sitting postures (Perich et al, 2006), deficits in lumbo-pelvic motor control (McGregor et al, 2002 Caldwell et al, 2003), limitations in anterior pelvic tilt (Reid and McNair, 2000; Caldwell et al, 2003; McGregor et al, 2007), deficits in back muscle and lower limb endurance (Roy et al, 1990; Perich et al, 2009) and a lack of flexibility in the hamstrings (Gajdosik, 1994; Reid and McNair, 2000) have all been reported in the literature as causative factors for LBP prevalence in rowers.

In the general population, LBP incidence has been associated with deficits in general conditioning, altered motor control patterns (Moffroid et al, 1994; O'Sullivan et al, 2003) and habitual positioning of the spine in postures associated with reduced activity of the spinal stabilizing muscles such as slump sitting (O'Sullivan et al, 2006). In addition, the inability to achieve anterior tilt in order to achieve neutral lumbar spine position can result in greater compressive forces on the lumbar spine in rowing (Caldwell et al, 2003). Rowers with LBP have been shown to spend a greater proportion of the drive phase during ergometer rowing near end-range lumbar flexion (above 90% full flexion) and females spend more time in the drive phase as compared with males (Ng et al, 2008a).

Reduced lower limb muscle endurance has been identified to be associated with LBP in female adolescent rowers (Perich et al, 2006). Greater fatigue of the back muscles (Perich et al, 2006) including lumbar multifidus muscles (Roy et al, 1990) have also been associated with LBP in rowing. Premature fatigue of the back and lower limb muscles in rowers may result in increased flexion loads being placed through the passive stabilizing structures of the spine.

Impairments in lower limb flexibility have the potential to influence lumbar spine position. A lack of hamstring flexibility in rowers has not been demonstrated to have an effect on LBP (Stutchfield & Coleman, 2006) however, this is contrary to previous studies in non-rowers which have demonstrated reduced hamstring flexibility in association with non specific LBP (Beiring-Sorensen, 1984; Halbertsma et al, 2001).

There are limited studies demonstrating the efficacy of specific exercise interventions for prevention of LBP in athletic populations. These intervention studies have utilised generic programs with mixed outcomes, instituting general core strengthening exercise programs in rugby players (Cusi et al, 2001) and in collegiate athletes (Nadler et al, 2002). These studies failed to demonstrate efficacy.

A recent study evaluating specific segmental muscle control exercises in young female gymnasts with and without LBP were directed at the transverse abdominis and multifidus muscles of the lumbar spine (Harringe et al, 2007). These segmental muscle control exercises, previously documented in the literature (Richardson & Jull, 1995; O'Sullivan et al, 1997) were delivered in a controlled group setting rather than on an individual basis and implemented into a weekly regular training regimen which may have improved adherence to the regimen. The experimental group who undertook 12 weeks of specific segmental muscle training demonstrated a significant reduction of days with LBP and reduced pain intensity compared with gymnasts in the control group. However, there were a number of methodological limitations of this study which included different sample sizes, non-randomisation of subjects, a lack of standardization of training programs and differences in anthropometric data between groups which limits the validity of the findings.

In a study of college rowers Tse et al (2005) investigated the effectiveness of an intervention aimed at improving the endurance of trunk muscles. An 8 week training program targeting transverse abdominis and multifidus muscles showed selective improvements in trunk endurance parameters however no improvements were shown in functional performance tasks (vertical jump, broad jump, shuttle run, 40 metres sprint, overhead medicine ball throw and a rowing ergometer test). The initial phases of trunk endurance training involved isometric exercises progressing to controlled mobility exercises during the 8 week program. Of interest, is the author's suggestion that improvements in trunk muscle endurance may be influential in preventing and reducing episodes of LBP, despite no data being collected on LBP prevalence in the college rowers.

Koutedakis et al (1997) investigated a sub-group of 22 female rowers who underwent a hamstring strength training program for 6-8 months. They concluded that the program contributed to improvements in knee flexor/knee extensor peak torques and a parallel reduction in the number of missed days training due to LBP. However in this study, LBP prevalence at the completion of the training program was not reported and the lack of a control group for comparison limits the validity of these findings.

To date, only one study has tested an individually applied, specific physiotherapy exercise intervention as part of a multi-dimensional intervention in a rowing population. This study was conducted in the 2006 schoolgirl rowing season in one private girls' school involving 90 subjects with and without LBP, with four other private girls' schools participating in the rowing season acting as the control group (Perich et al, 2009). The intervention involved an education session, musculoskeletal screening by experienced physiotherapists and an individually prescribed exercise program. The exercise program was designed to change sitting, lifting and rowing postures with progressive conditioning of the lower limbs and back muscles in these corrected postures, with the aim to reduce flexion spinal loading of the lumbar spine. A minimum of two follow up consultations were performed one week and three weeks following the initial screening to ensure adequate understanding and compliance of the individualised exercise program with subjects experiencing ongoing LBP receiving up to six physiotherapy reviews. General conditioning sessions aimed at improving aerobic conditioning, muscle strength and endurance, were also conducted in groups by the physical education teacher before or after on-water rowing sessions. There was also less on water rowing and more off water training. Following the intervention, there was a significant reduction in the prevalence of LBP in the intervention group as compared with the control group. The experimental group receiving the multidisciplinary intervention had a significantly lower prevalence of LBP (26%) across the rowing season when compared with the control group (46%). Changes in the prevalence of LBP were associated with changes in sitting posture as well as increased back and lower limb endurance in the intervention group. However, in this previous study, the education session, physical conditioning sessions, coaching or rowing/ergometer sessions were not controlled for, making it unclear as to the specific effect of the exercise intervention itself, in reducing LBP prevalence.

In light of these limited studies and the high prevalence of back pain experienced in sporting populations, clearly there is a need for further research to evaluate the benefits of individually prescribed exercise programs in sporting populations. Therefore, the aim of the current study was to determine the efficacy of the specific physiotherapy exercise intervention undertaken in the previous study within a field study, whilst controlling for the other components of the multi-dimensional intervention program. In addition, this study also examined the changes in lower limb flexibility and lower leg endurance in the group of adolescent females who participated in the physiotherapy intervention.

It was hypothesised that an individually applied specific physiotherapy intervention in adolescent female rowers (with and without LBP) would be more effective in reducing; the prevalence of LBP, the intensity of LBP and disability level when compared with the control group. A secondary hypothesis was that the experimental group would demonstrate an improvement in lower limb flexibility and isometric lower leg endurance at the end of the rowing season.

2.2 Materials and Methods

2.2.1. Ethical Approval

Ethical approval was granted for the undertaking of this research study prior to its commencement, by the Human Research Ethics Committee at Curtin University of Technology, Perth, Western Australia (Appendix A).

2.2.2 Subjects

There were 82 girls with and without LBP, aged 13-17 years, from a private girls school in Perth, Western Australia participating in the Independent Girls Schools Sports Association 2007 rowing season. The season (period of 23 weeks) was split into a pre-competition period lasting 11 weeks and a competition period, involving 5 regattas which lasted 12 weeks. Twenty-five subjects were required for each group to achieve a significant difference in prevalence with an alpha level of 0.05 and 80% power.

The design of this field study was a non-randomised controlled field study. This design was chosen as it best replicates real life clinical practice. All subjects (n=82) were offered the opportunity to participate in the physiotherapy intervention, with the fees associated being standard physiotherapy consultation charges. Subjects who indicated a willingness to undergo the intervention (n=36) were assigned to the experimental group while those who did not were assigned to the control group (n=46). Subjects and their parents were provided with an information sheet outlining the purpose of the study (Appendix B and C). A document of informed consent was completed by all subjects prior to participation in the study (Appendix D). Subjects were excluded from the study if they had pre-existing LBP due to previous spinal trauma unrelated to rowing, or diagnosed specific lumbar spine disorders such as spondylolisthesis, inflammatory disorders or neurologic conditions (n=1). The subjects who withdrew from each group throughout the rowing season were requested to fill in a questionnaire (Appendix E) outlining the reason for their withdrawal from the 2007 school rowing program. The subjects who withdrew were excluded from further analysis in this study (exp n=13, control n=10).

Figure 1 illustrates the flow of subjects through this non-randomised controlled trial outlining withdrawals, reasons for withdrawal and the proportion of subjects with LBP in each group.

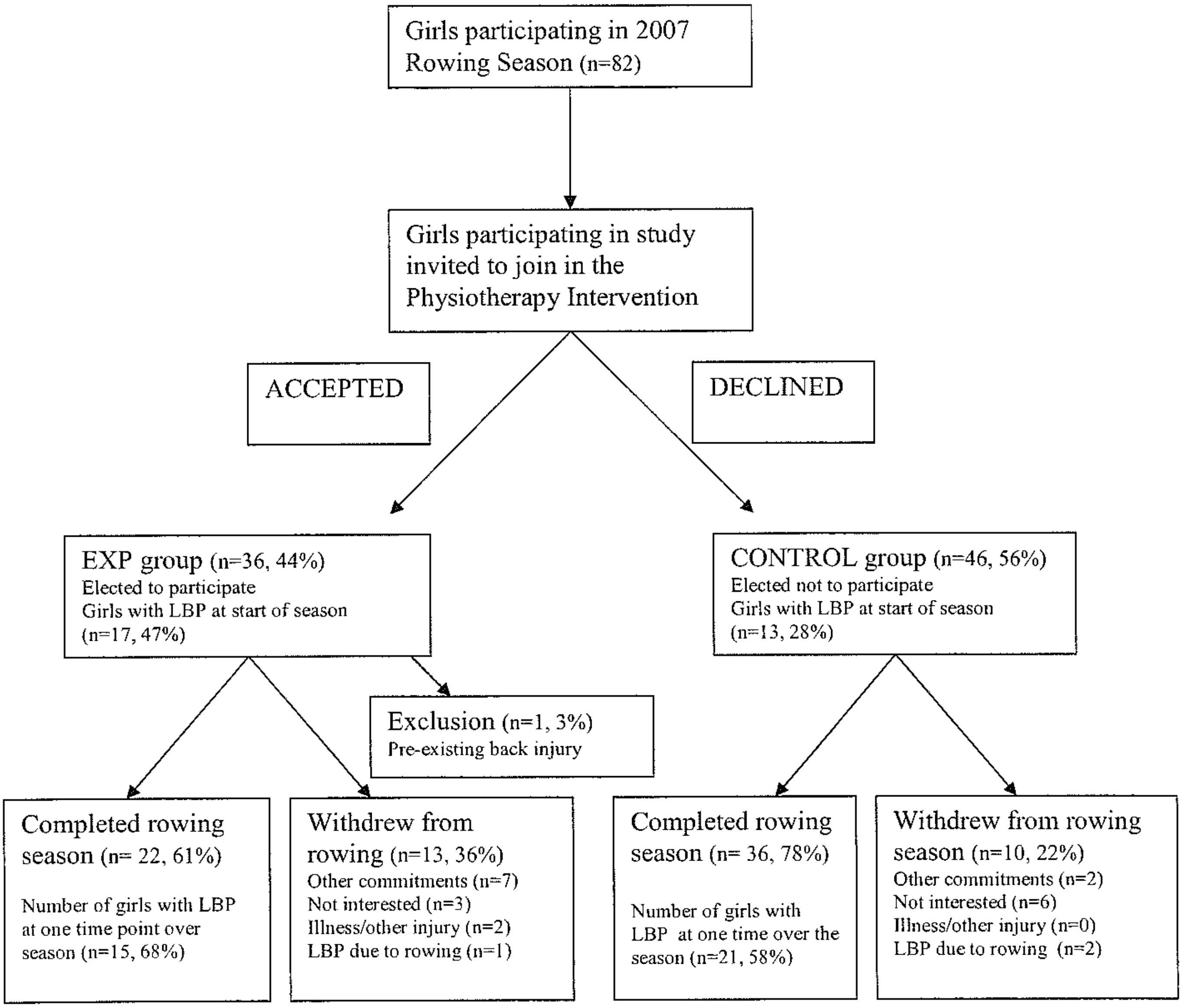

Figure 1. Flow diagram to outline the flow of subjects through this controlled trial. This figure also shows withdrawals, reasons for withdrawal and the proportion of subjects with LBP in each group.

2.2.3 Intervention

The format for the non-randomised controlled trial was:

(i) education session (experimental and control groups)

(ii) physiotherapy exercise intervention program (experimental group)

(iii) physical conditioning program (experimental and control groups)

(i) education session

The education session was conducted by the same experienced physiotherapist involved with the musculoskeletal screening in the previous study (Perich et al, 2009). The session was of 1 hour duration and all subjects from both groups, their parents, physical education staff and rowing coaches were requested to attend. This session covered concepts such as: basic spinal mechanics, injury risk in rowing, potential LBP mechanisms in rowing, spinal posture education (while sitting, rowing and lifting), attitudes and coping strategies with regards to the management of LBP. This included seeking prompt advice, informing parents and coaches of the presence of LBP and the use of early symptomatic relief.

(ii) physiotherapy intervention program

Subjects in the experimental group were then required to undergo a musculoskeletal screening assessment by an experienced physiotherapist. The first aspect of this involved an interview to assess current and previous history of LBP, pain location, aggravating and easing factors for LBP, as well as treatment history, attitudes towards LBP, current levels of rowing training and general activity. Following this, a musculoskeletal physical examination (Appendix F) was carried out in order to examine spinal range of movement, directional pain provocation, habitual spinal postures in sitting and standing and spinal repositioning sense in sitting. Lumbo-pelvic motor control was assessed by the ability to maintain a neutral lumbar spine with a relaxed thorax in sitting; whilst performing active hip flexion and knee extension;

forward reach in sitting; sit to stand; half squat (with 90 degrees hip and knee position); squat with forward reach; and the row position. Lower limb endurance was measured with a timed squat test (maintaining a neutral lumbar spine posture while in a squat position with 90° flexion at the hips and knees). The timed squat test was utilized in the previous study by Perich et al (2008), to measure improvements in lower limb endurance following the intervention program. Lower limb flexibility was measured with the sit and reach test. The sit-and-reach test has illustrated an increased likelihood of diagnosed LBP associated with both reduced hamstring/lumbar spine flexibility and increased hamstring/lumbar spine flexibility (Perry et al, 2009). Rowing technique and the ability to control end range lumbar flexion postures was assessed visually on the rowing ergometer.

An individually prescribed exercise program (Appendix G) as part of the physiotherapy intervention was instituted for subjects with and without LBP, based on the findings identified in the musculoskeletal screening. This program addressed the individual limitations which were recognised as having a potential to cause LBP for the subject while rowing, such as a lack of ability to maintain lumbo-pelvic control under flexion load. Each subject received a total of three physiotherapy sessions, with review at one and three weeks following the initial screening to ensure adherence and understanding of the exercise programs and to progress the exercises. There was no other physiotherapy treatment or manual therapy administered. A team of 8 musculoskeletal and sports physiotherapists who were experienced in the assessment and exercise prescription protocol participated in the physiotherapy intervention. Individual exercises which formed part of the physiotherapy intervention were sitting posture, sitting knee lift, sitting forward bend, kneeling squat, endurance squat, endurance hold in a simulated row position while maintaining a neutral lumbar lordosis with the addition of thoracic flexion.

Subjects in the experimental group received a rowing flexibility sheet (Appendix H) and rowing exercise sheet (Appendix I) with their individual physiotherapy intervention displayed in picture form, with a brief explanation of the exercises. Subjects were requested to undertake the physiotherapy intervention daily throughout the course of the rowing season and the rowing coaches, physical education staff and parents were requested to continually reinforce the physiotherapy intervention during the rowing season. Subjects were asked to fill in a compliance sheet (Appendix J) to indicate if the exercises were undertaken, however these data were not collected as there was poor adherence to completing the compliance sheet.

(iii) physical conditioning program

The physical conditioning program used in this study was the same as that used in the previous study by Perich et al (2009). This program was designed to increase lower limb and back muscle endurance, enhance general conditioning and improve postural awareness. The implementation of the physical conditioning program was undertaken by the school's rowing coaches and physical education staff and remained a constant between groups in this study. Activities included in this program consisted of aerobic conditioning, hill running, strength and conditioning circuits and flexibility training. The researcher liaised with the physical conditioning instructor, after the completion of the physiotherapy intervention, in order to reinforce squat and rowing specific exercises for subjects in both groups as part of their physical conditioning program. The researcher also attended two physical conditioning sessions after the completion of the physiotherapy reviews to firstly reinforce the squat and rowing specific exercises and secondly to reinforce compliance with the intervention program subjects in the experimental group.

2.3. Data Collection and Analysis

2.3.1 Anthropometric measures

Age, height and weight measures were collected to ensure similarities in the trial sample between both groups.

2.3.2 LBP Prevalence and Aggravating Factors

LBP prevalence was determined by asking the question at baseline pre-season "Have you experienced low back pain?" and at mid-season, end-season and post-season asking the question "Have you experienced back pain since the commencement of the rowing season?" and "Do you currently experience LBP while rowing?" LBP prevalence was determined mid-season, end-season and post-season by a positive response to both questions. A questionnaire was completed examining factors that 'bring on' or 'exacerbate pain' in relation to rowing, ergometer training and lifting the boats (Appendix K).

2.3.3 LBP Location

Subjects were requested to fill in a body chart illustrating the area they currently experienced back pain (Appendix L).

2.3.4 LBP Intensity

Subjects were asked to rate their pain on a 10cm visual analogue scale (Appendix M) with the start point on the left side of the horizontal line being "no pain" and the end point on the right side of the line being the "worst pain imaginable". A percentage score was recorded. This method of measuring pain intensity is both reliable and valid (Jensen et al, 1986; Ogon et al, 1996).

2.3.5 LBP Disability

Subjects were asked to complete the modified Oswestry questionnaire (Appendix N) which is a reliable and valid measure of function consisting of nine sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life and travelling. (Fairbank & Davies, 1980). The section relating to sex life was deleted for this study, however the test still retains its validity (Page et al, 2002). Subjects selected the statement in each section which was most appropriate to their level of disability and a percentage score was recorded.

These questionnaires were collected at the beginning of the rowing season (week 1), mid-season (week 11), end-season (week 23) and 10 weeks post-season (week 33) (Appendix O, P & Q).

2.3.6 Secondary outcome measures for experimental group

Two secondary outcome measures were taken in week 1 and week 23 for the experimental group.

(i) Sit and Reach Flexibility Test

Subjects were placed in long sitting on a bench and asked to flex forward and reach their toes (held in maximum dorsiflexion) as far as they could while keeping their knees straight. This position was held for three seconds and a measurement taken in negative centimetres before reaching the toes and positive centimetres over the toes. The sit and reach test, to evaluate lower limb flexibility, was described by Larson (1974) and has been shown to be a reliable measure (Mikkelsson et al., 2006).

(ii) Isometric Lower Limb Endurance

Subjects were instructed to perform a timed isometric semi-squat posture with the hips and knees postured at 90 degrees. Subjects were instructed to cease this semi-squat hold if their LBP level rose above 3/10 on a visual analogue scale or they were no longer able to maintain the lumbo-pelvic posture instructed or their legs fatigued.

2.4. Statistical Analysis

An independent t-test was performed on the baseline data, to assess for group differences with regard to anthropometric data of height, weight and age at entry to the trial.

An independent t-test was performed on the baseline data of subjects with LBP in each group to assess for group differences with regard to VAS and Oswestry scores at entry to the trial.

Point prevalence was compared at four occasions over the rowing season (pre-season, mid-season, end-season and post-season) between the control and experimental groups. Prevalence of LBP was defined as pain intensity of a VAS score greater than 1, in order to eliminate low levels of discomfort associated with rowing and muscle fatigue. Logistic regression was used to model the proportions pain-free over the 4-time points for both the control and experimental groups. Within-subject correlation over the times was taken into account for calculation of standard errors and assessment of parameter estimates using a Wald Chi-square test statistic.

Of the subjects with LBP, the mean VAS and mean Oswestry scores in the experimental and control groups were reported descriptively at the four points over the rowing season.

A non-parametric test was used in the statistical analysis as the data was not normally distributed and skewed due to not all subjects experiencing LBP at baseline or at one of the time points throughout the rowing season. Hence, a Mann Whitney-U non-parametric test was used to assess differences in change scores of pain intensity and disability levels between the two groups, in subjects with LBP, across the time frame (the difference between the baseline pre-season score and the mid-season, end-season and post-season score for each individual) of each measure, to assess differences between the two groups after the intervention period. This test was performed to account for the large number of zero scores for subjects without back pain, resulting in a zero inflation effect.

A within-measures t-test was used to analyse secondary measures of sit and reach flexibility and isometric lower limb endurance in the experimental group.

The level for statistical significance was set at the 95% confidence limit. The power calculation of 25 subjects was calculated for the primary outcome measure of prevalence based on the results of the previous study by Perich et al (2008). Statistical analysis was performed using Microsoft Excel and SPSS software version 15.

2.5. Results

2.5.1 Baseline data

There was no significant difference in baseline data illustrated in table 1 with regards to age, height and weight between the experimental and control groups. Pre-existing LBP prevalence (VAS score greater than 1 out of 10) was recorded at baseline pre-season. Differences in prevalence at baseline were found to be statistically significant and are illustrated in table 1. Statistical analysis demonstrated no significant difference in baseline levels of pain intensity and disability in subjects with LBP, between groups.

Table 1. Baseline measures of anthropometric data, prevalence, pain intensity and disability of all subjects involved in the 2007 school rowing program

	EXPERIMENTAL (n=36) Mean (SD)	CONTROL (n=46) Mean (SD)
Age	13.9(0.9)	13.8(1.0)
Height	167.4(10.6)	168.1(8.2)
Weight	58.9(8.0)	58.4(9.04)
Prevalence VAS > 1	48%	22%
Pain Intensity Mean VAS (mm)	32.5(14.5) (n=10)	25.4(7.7) (n=8)
Disability Mean Oswestry %	5.3(4.6) (n=10)	5.4(4.3) (n=8)

Pain intensity (mean VAS) and disability (mean oswestry) refer to those subjects at baseline who currently experienced LBP.

2.5.2 Withdrawals

Table 2. Baseline measures of anthropometric data, proportion of withdrawals, pain intensity and disability of subjects who withdrew from the 2007 school rowing program

	EXP (n=12) Mean (SD)	CONTROL (n=10) Mean (SD)
Age	14.2(1.4)	13.5(0.5)
Height	166.2(6.6)	165.0(6.0)
Weight	55.5(8.4)	51.3(7.4)
Proportion of subjects who withdrew	33%	22%
Pain Intensity Mean VAS (mm)	46.1(22.4)	13.9(5.6)
Disability Mean Oswestry (out of 100)	5.6(7.0)	4.0(0)

The data in table 2 suggest that the subjects who initially volunteered to be part of the experimental group who later withdrew from the study had a trend towards higher levels of pain intensity at baseline pre-season than those who remained in the experimental group intervention program and than those who withdrew from the control group. The subjects who withdrew from each group were requested to fill in a questionnaire outlining the reason for their withdrawal from the 2007 school rowing program which is cited in figure 1. The subjects who withdrew from the school rowing program were excluded from further analysis in this study. One subject in the experimental group was excluded from the study due to sustaining a traumatic lifting injury to the low back (independent of rowing) prior to the commencement of the 2007 rowing season.

2.5.3 Aggravating Factors and Location of Pain

The self-reported factors related to rowing that caused the initial onset or exacerbated LBP in those subjects with LBP due to rowing were recorded: lifting the boat (exp n=6, control n=3), sweep rowing (exp n=8, control n=4), rowing in quadruple or single scull (exp n=7, control n =1), ergometer rowing (exp n=11, control n=4), long rowing sessions (exp n=6, control n=4) or other issues related to sustained postures or weight training (exp n=4). The location of pain was identified as lumbar (exp n=13), thoracic (exp n=4), buttock (exp n=1). Six subjects also reported shoulder pain.

2.5.4 LBP Prevalence

LBP prevalence was defined for the remaining subjects in each group on the basis of a VAS score greater than 1, in order to eliminate low levels of discomfort associated with rowing and muscle fatigue.

Table 3. LBP % point prevalence VAS > 1 at the four time points during the rowing season for subjects who completed the rowing season.

	Pre-season %	Mid-season %	End-season %	Post-season %
Exp (n=22)	47.9	19.0	23.8	28.6
Control (n=36)	22.2	25.0	22.2	13.9

Table 3 records the percentage point prevalence at the four time points during the rowing season. Figure 2 illustrates the experimental group demonstrated a reduction in the prevalence of LBP across the rowing season from 48% to 19% (representing a reduction of 29%) pre-season to mid-season and from 48% to 24% (representing a reduction of 24%) pre-season to end-season while in the control group the prevalence of LBP slightly increased from 22% to 25% (representing a 3% increase) pre-season to mid-season and was unchanged at 22% (0% change) pre-season to end-season. This was in spite of a significantly greater number of subjects in the experimental group having pre-existing LBP.

A between-group comparison of the proportions pain-free for each of the 4 time points found the two groups differed significantly only at baseline pre-season (p=0.05). Modeling within-group changes across the times revealed there was a significant increase in the proportion pain-free in the experimental group at mid-season as compared with pre-season (p=0.007) but no change thereafter (p>0.05), indicating a significant reduction of LBP prevalence in the experimental group after the intervention. Within the control group the proportion pain-free remained relatively stable across the 4 times (p>0.2) for changes between consecutive times.

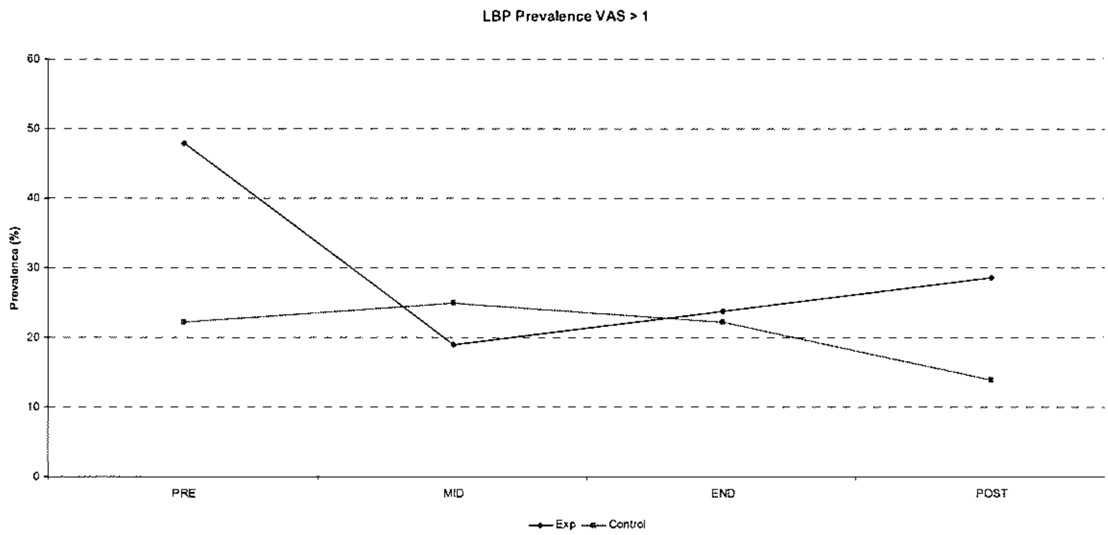

Figure 2. LBP Point Prevalence VAS > 1 (n=58) Point prevalence values were recorded for subjects in both groups who completed the rowing season.

2.5.5 Changes in Pain Intensity and Disability

Measures of pain intensity and disability were recorded at the four time points during the rowing season. Tables 4 and 5 show the mean pain intensity and disability level scores for subjects with LBP. To account for the number of subjects who were pain free at different time points over the season, the changes in pain intensity and disability level in the individual subject during the rowing season were the basis for the statistical analysis of primary outcome measures of pain intensity and disability level.

Table 4. Mean VAS pain intensity scores (VAS mm) for girls with LBP in each group

	Pre-season Mean (SD)	Mid-season Mean (SD)	End-season Mean (SD)	Post-season Mean (SD)
EXP (n=36)	32.5(14.5)	31.4(12.0)	34.6(26.2)	25.3(8.9)
CONTROL (n=46)	25.8(7.7)	34.7(22.9)	36.3(16.1)	23.5(12.3)

Table 5. Mean Oswestry disability level scores (out of 100) for girls with LBP in each group

	Pre-season Mean (SD)	Mid-season Mean (SD)	End-season Mean (SD)	Post-season Mean (SD)
EXP (n=36)	5.3(4.6)	5.2(3.4)	4.0(3.4)	5.0(1.7)
CONTROL (n=46)	5.1(4.3)	7.3(7.1)	7.5(5.8)	9.4(6.6)

Six subjects in the experimental group and 10 subjects in the control group reported no pain at any stage during the rowing season. Changes in pain intensity and disability levels (the difference between the baseline pre-season score and the mid-season, end-season or post-season score) were calculated and the results are illustrated in tables 6 and 7.

Table 6. Pain intensity as measured by VAS out of 100 – mean (SD). Difference in change score are recorded pre-season to mid-season, pre-season to end-season and pre-season to post-season for subjects who completed the rowing season.

	VAS pre-mid season	VAS pre-end season	VAS pre-post season
Control Mean (SD) n= 36	-4.16 (22.6)	-5.34 (24.55)	7.2 (16.71)
Exp Mean (SD) n= 22	7.79 (22.42)	10.95 (26.84)	14.4 (23.7)
P value	0.635	0.022	0.226

Table 7. Disability level as measured by Oswestry out of 100 – mean (SD). Difference in change score are recorded pre-season to mid-season, pre-season to end-season and pre-season to post-season for subjects who completed the rowing season.

	OSW pre-mid season	OSW pre-end season	OSW pre-post season
Control Mean (SD) n= 36	-4.12 (7.1)	-3.88 (7.06)	-3.33 (7.35)
Exp Mean (SD) n= 22	0.36 (7.9)	0.73 (7.39)	1.8 (6.3)
P value	0.374	0.852	0.689

Changes in VAS score across the rowing season was defined as a positive score for a reduction in VAS (decrease in levels of pain) and defined as a negative score for an increase in VAS. There was a significant difference in pain intensity VAS change scores between groups, when comparing end-season score with baseline pre-season score [mean pre-end season exp 6.4(21.0), control -2.7(17.6) Z= -2.283, p = 0.022]. This illustrates a significant reduction in pain intensity over the course of the rowing season for the experimental group who received the physiotherapy intervention. Although statistical analysis of change score data pre-season to mid-season and pre-season to post-season did not illustrate a significant difference, the graph in figure 3 demonstrates a consistent trend towards a reduced level of pain intensity, when comparing pre-season to mid-season and pre-season to post-season.

Differences in change scores of pain intensity and disability levels between groups across the time frame are illustrated in figures 3 and 4.

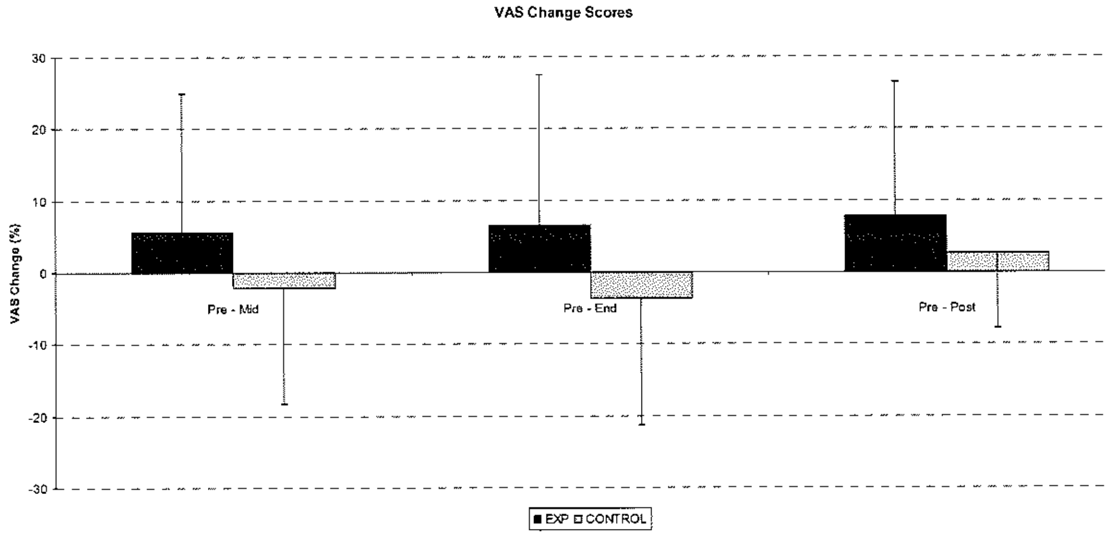

Figure 3. Pain intensity change score means (SD) for subjects with LBP in each group
The change in VAS score is defined as a positive score for a reduction in pain intensity and defined as a negative score for an increase in pain intensity. Statistical analysis was a comparison of the difference in change scores between groups.

Changes in Oswestry scores across the rowing season were defined as a positive score indicating reduced levels of disability and defined as a negative score indicating an increase in levels of disability. Statistical analysis of changes in the level of disability (Oswestry) mid-season, end-season and post-season when compared with baseline pre-season did not illustrate significant differences between groups. However, figure 4 suggests a trend for slightly greater levels of disability in the control group across the rowing season as compared with the experimental group.

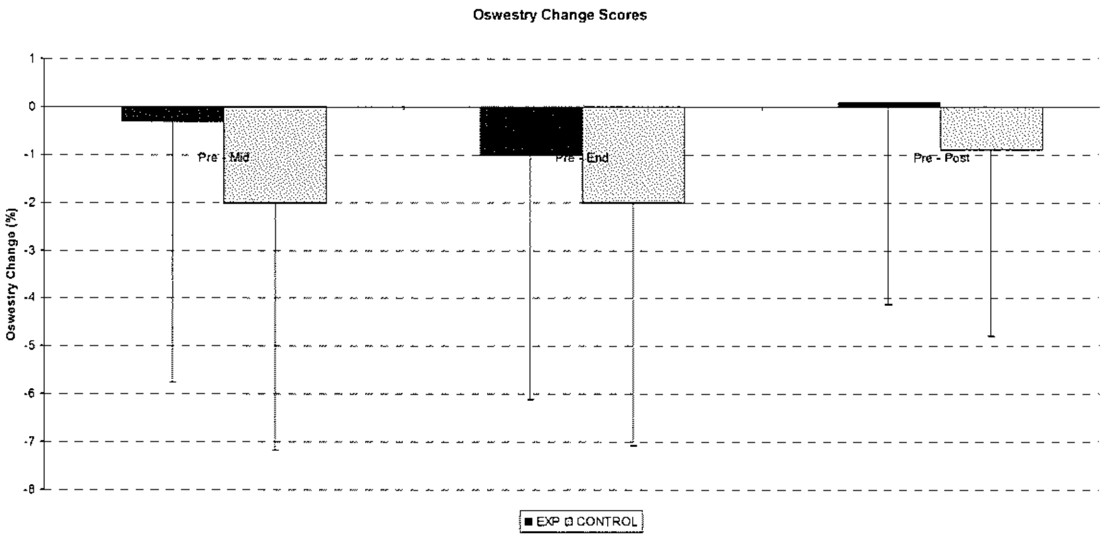

Figure 4. Disability level change score means (SD) (Oswestry) for subjects with LBP in each group. The change in Oswestry score is defined as a positive score for a reduction in disability level and defined as a negative score for an increase in disability level. Statistical analysis was a comparison of the difference in change scores between groups.

2.5.6 Secondary outcome measures in experimental group

Secondary outcome variables in the experimental group were analysed using paired t-tests. Lower limb flexibility (pre-season mean$\pm$SD 5.7$\pm$9.7cms, end-season 8.9$\pm$8.4cms) demonstrated a significant difference between pre-season to end-season range ($p<0.05$). Isometric lower limb endurance (pre-season mean$\pm$SD 59.8$\pm$24.8seconds, end-season 218.6$\pm$134.7) also demonstrated that there was a significant difference between pre-season to end-season endurance ($p<0.05$).

2.6 Discussion

The current study tested the efficacy of the specific physiotherapy intervention in isolation that was a component of the multi-dimensional study previously undertaken in the study by Perich et al (2008). Eighty one rowers, who had no previous exposure to the specific physiotherapy intervention program, from one school participating in the 2007 school rowing season, participated in the current study. Although it is acknowledged that there are inherent limitations with a 'field study' design, the advantage of this methodology is that it closely reflects 'real life' clinical practice.

2.6.1 LBP Prevalence

In support of our hypotheses, the principal findings of this study support that the specific physiotherapy intervention resulted in a reduction in the prevalence of LBP across the rowing season in the experimental group when compared with the control group. This change revealed a 29% reduction in LBP prevalence in the experimental group with a 3% increase in the control group across the rowing season. This was demonstrated with a statistically significant increase in the proportion of subjects pain-free in the experimental group when comparing mid-season to pre-season, but no change thereafter. The proportion of subjects pain-free in the control group remained relatively stable across the four time points of the rowing season. It is acknowledged that the self-selection bias for the physiotherapy intervention may have had the potential to provide a greater chance for the experimental group with a higher pain prevalence and an expectation for treatment to improve their status. In spite of this, whilst controlling for the education session, physical conditioning programs and coaching components of the intervention the findings support that the physiotherapy intervention had a significant impact on the prevalence of LBP in this population. This is in line with previous research by Perich et al (2009) which demonstrated a reduction in prevalence of up to 12% across the rowing season in the experimental group following the multi-dimensional intervention. Certainly, the high prevalence rates of LBP in adolescent female rowers is an important issue which needs to be acknowledged and addressed by schools offering rowing programs to this population.

2.6.2 Pain Intensity in Subjects with LBP

The hypothesis that there would be reduced levels of pain intensity in the experimental group as compared with the control group was also supported. For subjects with LBP in the experimental group there was a significant reduction in pain intensity across the rowing season. Statistical analysis demonstrated a significant difference in individual changes in pain intensity at end-season as compared with baseline pre-season in the experimental group whereas the control group showed unchanged levels of pain intensity across the rowing season. The results in the current study indicate that the specific physiotherapy intervention not only reduced LBP prevalence in the experimental group, but was also effective in reducing pain intensity in those subjects with existing LBP.

2.6.3 Disability Levels in Subjects with LBP

The hypothesis that there would be reduced levels of disability in the experimental group as compared with the control group was not supported statistically, although there was a trend towards reduced disability levels in the experimental group across the rowing season. It is important to note that in both groups, the reported baseline level of disability was low and remained low throughout the rowing season suggesting that the LBP experienced had little impact on activities of daily living as measured by the modified Oswestry questionnaire. This finding may reflect a lack sensitivity of the questionnaire to disability related to rowing in an adolescent population. It is reported that the Oswestry questionnaire is more sensitive to moderate rather than low levels of disability (Roland & Fairbank, 2000). Conversely it may be that these subjects coped well with their LBP.

2.6.4 Secondary variables of lower limb flexibility and lower limb endurance

The results support the secondary hypothesis tested, that there would be significant improvements in measurements for both lower limb flexibility and isometric lower leg endurance. Improvements in lower limb endurance and lower leg strength are likely at the culmination of the rowing season and may be associated with reduced LBP prevalence. As these results were not assessed in the control group, it is not known whether these finding were simply a response to the rowing program, rather than the intervention.

2.6.5 Exercise Interventions

Overall knowledge of the impact of specific physiotherapy exercise interventions on the effect on LBP in sporting populations is very limited. As part of clinical physiotherapy practice, exercise prescription by physiotherapists formulates a significant portion of the treatment and management of athletes. The lack of evidence base reported in the literature beggars the question as to the validity of the many physiotherapy exercise interventions which are prescribed on a daily basis.

Many sporting groups undertake 'trunk strengthening' or 'core stability training' in an attempt to reduce the prevalence and pain or disability associated with LBP. However there is a paucity of evidence base in the literature to support the benefits of such conditioning. Generic exercise programs where 'core strengthening' and 'trunk strengthening' exercise programs have been delivered in group settings have shown no significant benefits from the intervention (Nadler et al, 2002; Cusi et al, 2001). Specific muscle control exercises delivered in a group setting as part of weekly training regimen were of benefit in reducing pain intensity and functional disability in adolescent gymnasts, however the authors acknowledge a number of methodological limitations in the research design (Harringe et al, 2007).

This current study adds to the evidence base for specific physiotherapy exercise interventions. The only previous study of a similar nature was in adolescent female rowers whereby the specific individualised physiotherapy intervention formed one component of a multi-disciplinary program (Perich et al, 2009). The current findings are consistent with the previous study in adolescent female rowers; however, in this study the specific physiotherapy intervention in isolation was effective in reducing the prevalence of LBP and in reducing pain intensity levels in the experimental group across the rowing season.

2.6.6 Limitations

The present study has a number of methodological limitations which need to be acknowledged. This non-randomised controlled study was conducted as a field based study where the subjects elected to participate in the physiotherapy intervention. The uneven group size was the result of more subjects with LBP self selecting for the physiotherapy intervention, causing a self-selection bias. This may have the potential to provide more chance for the experimental group with a higher pain prevalence to improve pain prevalence itself. Despite the bias towards self selection, the significant reduction in LBP prevalence and pain intensity levels at the end of season in the experimental group suggested that the physiotherapy intervention was effective.

Low numbers in each group who completed the rowing season were due to withdrawals from the rowing program within the school. There were a high number of withdrawals from each group, with the baseline pain intensity level in the subjects who withdrew, higher in the experimental group. In spite of this, it is interesting to note that LBP was cited as a reason for withdrawing from the rowing program in only 3 subjects (exp group n=1, control group n=2).

The lack of randomization and blinding in this study is also considered to be a limitation. Although it was possible that the intervention may be observed by the control group, the fact that the physiotherapy intervention was based on individual screening and an individually prescribed exercise program, it is unlikely subjects in the control group had the understanding and knowledge to adequately perform the physiotherapy intervention as a result of observing subjects in the experimental group do their exercises.

Statistical analysis involved multiple testing of point prevalence, pain intensity and disability level. A confidence interval was set at 95%, which was based on the point prevalence findings in the previous study by Perich et al (2008), with the potential for a significant result occurring by chance with p-value set at 0.05.

As standard physiotherapy consultation fees were charged to the subjects receiving the physiotherapy intervention, the potential self selection bias could be based on an economic decision by the family of the subject.

Because of the study design limitations, the strength of these findings is reduced. Questions such as the input and level of support from the physical education and coaching staff within the school and level of compliance amongst subjects in the experimental group have not been answered.

2.7 Recommendations

Future studies with a randomised controlled design and long term follow-up using more sensitive disability measures are needed to evaluate the true effectiveness of this physiotherapy exercise intervention. The physiotherapy intervention needs unequivocal support from the rowing coaches and physical education staff who implement the physical conditioning program within the school. The physical conditioning program may benefit from the physiotherapist involved in the musculoskeletal screening and intervention to assist in implementing a physical conditioning program which better complements the physiotherapy intervention. However the results of the study reflect the real life situation of clinical practice and exercise prescription in a sporting environment.

2.8 Conclusions

The finding of this field study support that a specific individually prescribed physiotherapy exercise intervention was associated with a reduction in the prevalence of LBP in a population of adolescent female rowers across a rowing season. Reduced levels of LBP intensity in subjects who received the physiotherapy intervention was also observed although there were no statistically significant changes in disability levels across the rowing season. These findings need to be supported by randomised controlled study before their validity can be assured.

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Chapter 3

3.1 Discussion

Previous research by Perich et al (2006, 2009) and the results of this Masters study outline the high prevalence of LBP in adolescent female rowers. Rowing as a school sport is considered a prestigious event on the annual sporting calendar and experiences high participation rates in the private girls school IGSSA competition. Schools which offer such rowing opportunities to their students have a duty of care to ensure the program that is offered to the girls within their school recognises the high prevalence rates of LBP and adopts appropriate measures to redress it.

The primary aim of this study was to investigate the effect of a preventive strategy for LBP in a group of schoolgirl rowers. Specifically, the aim of the study was to determine the efficacy of the specific physiotherapy exercise intervention undertaken in the study by Perich et al (2009), whilst attempting to control for factors such as education, consistencies in coaching input and physical education staff input to conditioning programs across both groups.

The current results demonstrated a significant reduction in the prevalence of LBP across the rowing season in the girls who undertook the specific individually prescribed physiotherapy exercise intervention as compared with the control group which demonstrated no change or slight increases in LBP prevalence across the rowing season. The findings support the previous research by Perich et al (2009), suggesting that the specific physiotherapy intervention was effective in targeting individual risk factors of the rower. In addition, there was a significant reduction in pain intensity over the course of the rowing season in the intervention group which was not demonstrated in the control group. While there are inherent limitations with a field study design, the results lend support for the efficacy of this intervention.

3.2 A model for the management of LBP in sporting populations

The findings of this research contribute to the development of a new model for the management of LBP in sporting populations. This model encompasses not only the identification of sports specific risk factors but also the identification of individual risk factors of the athlete participating in that sport. Establishing these sports specific risk factors and individual risk factors enables an exercise intervention to be tailored to the specific needs of the athlete participating in that particular sport. It is likely that such a program would be an effective means of reducing LBP prevalence and would be potentially relevant to many different sports.

3.3 Sports specific risk factors

Knowledge that sports specific risk factors have the potential to increase LBP prevalence are well documented in the literature. It has been previously reported that participation in a number of different sports such as gymnastics (Tertti et al, 1990), fast bowling (Ranson et al, 2008), cycling (Burnett et al, 2004) and rowing (Perich et al, 2006) increases the risk of LBP prevalence.

In a study of risk factors associated with fast bowling in cricketers, Ranson et al (2008) demonstrated a predominance of risk factors associated with the sport of fast bowling such as repetitive flexion and extension, combinations of rotation and flexion/extension and high training loads and volumes. The study reveals that the sports specific risk factors, and not the individual risk factors, were found to be associated with back injury and stress fractures.

Specifically in the sport of rowing, there is significant evidence reported in the literature identifying sports specific risk factors which might influence the possibility of injury to the lumbar spine structures. These risk factors which have been previously discussed include repeated flexion, combinations of flexion and rotation, sustained sitting and training volumes and loads (Howell, 1984; Caldwell et al, 2003; Rumball et al, 2005; Burnett et al, 2008).

Therefore, it is well recognised that LBP may be more prevalent in the sport of rowing due to the cyclic action, high endurance demands and combinations of flexion and rotation of the lumbar spine.

3.4 Individual risk factors

The literature also reports significant evidence of individual risk factors relating to rowing. These factors (previously discussed in this thesis) include sitting posture, spinal kinematics when rowing, lumbo-pelvic motor control, back muscle endurance, lower limb endurance and hamstring length (Adams & Dolan, 1995; Reid & McNair, 2000; Caldwell et al, 2003, Perich et al, 2006).

Habitual or sustained passive sitting postures have the potential to increase flexion loading and sensitise the lumbar spine to flexion. O'Sullivan et al (2002) illustrated that the lumbo-pelvic stabilising musculature is active in maintaining optimally aligned, erect postures, and that these muscles are less active during the adoption of passive postures. Dunk et al (2009) reported that the lower three intervertebral joints of the lumbar spine approached their total flexion angles in the slouched sitting posture. These findings suggest there could be increased loading of the passive spinal structures in prolonged slouched sitting. O'Sullivan et al (2002) suggest the practice of postural retraining when facilitation of the lumbo-pelvic stabilising musculature is indicated in the management of specific spinal pain conditions associated with flexion loading sensitisation. As rowers spend significant time in a sitting position in the rowing shell or on a rowing ergometer, clearly the adopted sitting posture of the individual has the potential to affect the loads placed on the lumbar spine. This notion is supported by the findings of Ng et al (2008) who demonstrated that rowers with back pain spent more time at end range flexion during the drive phase of rowing than rowers without LBP. Facilitating lumbo-pelvic control during the drive phase of rowing may have the potential to reduce the time spent in end range flexion and therefore reduce the load on the lumbar spine. Further kinematic research undertaken while rowing is required to determine the exact effect of the exercise intervention on rowing kinematics.

Few reported intervention studies have attempted to alter identified individual risk factors for a specific sport, in order to determine the effect on LBP prevalence. This may, in part, contribute to the lack of knowledge regarding the efficacy of specific physiotherapy exercise interventions to prevent LBP in sporting populations.

In a non-sporting population, comparison of general exercise, motor control exercise and spinal manipulative therapy was undertaken by Ferreira et al (2007) in a group of 240 adults with LBP of greater than three months duration. Although they demonstrated motor control exercise provided slightly better short term improvements in function (three months) and perceptions of beneficial effect than general exercise, there were no differences in the medium to long term (six to twelve months). The general exercise program was administered in groups, whereas the motor control exercise was administered on a one-to-one basis. This study lends some support to the provision of individualised intervention programs in the management of LBP. However, the effectiveness of such an individualised intervention in specific sporting populations is yet to be determined.

A systematic review of research into the benefits of exercise therapy for non specific LBP in non-sporting populations suggest there is strong evidence that exercise therapy is at least as effective as other conservative treatments in the management of chronic LBP (Hayden et al, 2005). Individually designed strengthening or stabilising programs appear to be effective in decreasing pain and improving function (Hayden et al, 2005). These findings were supported by Taylor et al (2007) in an alternative systematic review who concluded that therapeutic exercise was more effective if it was relatively intense, and there were indications to suggest that more targeted and individualised programs might be more beneficial than standardised programs. Although evidence for targeted exercise interventions addressing individual physical risk factors for the development of LBP is supported by the literature in general LBP populations, there is little evidence in the literature to support these findings in sporting populations.

3.5 Exercise interventions addressing risk factors

There is little reported literature outlining management strategies to address sports specific risk factors and identified individual risk factors across all sports and in particular rowing. In spite of this, exercise prescription by physiotherapists in clinical practice often formulates a significant portion of the treatment and management of athletes. The validity of these physiotherapy exercise interventions which are prescribed on a daily basis may be questioned due to a lack of evidence base for these interventions. Hayden et al (2005) suggested that individually designed exercise programs may improve pain and function in non-specific LBP. A systematic review of therapeutic exercise (defined as the prescription of a physical activity program that involves the client undertaking voluntary muscle contraction with the aim of relieving symptoms or improving function) determined that therapeutic exercise was beneficial across broad areas of physiotherapy practice (Taylor et al, 2007). Clearly, there is the need to determine if these exercise interventions are proven to be effective when addressing both individual and sports specific risk factors.

For instance, many sporting groups undertake 'trunk strengthening' or 'core stability training' in an attempt to reduce the prevalence and pain or disability associated with LBP (Nadler et al, 2002; Harringe et al, 2007). The basis for these interventions is the presumption that a lack of conditioning or 'core stability' is the underlying basis to the LBP disorder. However, these studies do not present clear evidence that the sporting groups lack conditioning or 'core stability'.

Cholewicki et al (2005) found that altered trunk muscle timing was associated with a greater risk for LBP over a 2-3 year period in a group of college athletes. A recent study highlighted that recurrent LBP was associated with excessive trunk stiffness to perturbation, questioning the basis of the "core stability" model of management of LBP (Hodges et al, 2009). Previous intervention programs have based their approach on current clinical beliefs rather than identification of specific impairments of the individual in specific sporting populations. Current clinical practice prescribing exercise interventions are not clearly evidence based. In addition, these generic exercise interventions have often been delivered in group settings, not addressing individual needs of the athletes and have failed to demonstrate efficacy (Cusi et al, 2001; Nadler et al, 2001; Tse et al, 2005; Harringe et al, 2007).

(i) generic exercise interventions

In the study by Nadler et al (2002), the incidence of LBP and hip muscle strength following the implementation of a core strengthening program in a group of collegiate athletes was investigated. In this study, collegiate athletes across a number of different sports were evaluated by questionnaire for LBP incidence and underwent isokinetic testing for hip muscle strength. However, no sports specific risk factors were identified. Individual differences in hip muscle strength (abductors and extensors) were measured on consecutive years before and after implementing the core strengthening program. Athletes receiving treatment for LBP were recorded and no significant difference in LBP incidence was demonstrated following implementation of the core strengthening program. This study demonstrated increases in hip extensor strength following implementation of the core strengthening program, however this did not correlate with reductions in LBP incidence. The 'core strengthening with an emphasis on abdominal, paraspinal and hip extensor strength' was instituted over a training season and was not based on individual deficits identified in the athlete. Identification of the factors associated with a pain disorder is likely to be a critical preliminary step before an intervention is designed and implemented.

In the study by Harringe et al (2007), an adolescent population of gymnasts with and without LBP, participated in the study over a 12 week period. Sports specific risk factors related to the sport of gymnastics such as high velocity tumbling which may include rotation, were recognised as contributing to the prevalence of LBP. Individual risk factors related to the physical characteristics of the gymnast were not assessed. Measurements of LBP prevalence were taken with a daily questionnaire utilizing a body chart and the intensity of pain was measured with Borg's category-ratio scale.

An intervention program targeting specific segmental muscle control exercise was instituted by a physiotherapist to the intervention group, with the instructions for the intervention carried out to the entire group, at the same time. The assumption was that all gymnasts required the same intervention and did not take individual differences in physical characteristics into account. The intervention was based on an isometric co-contraction of transverse abdominis and lumbar multifidus muscles in prone lying, four point kneeling with progression to co-contraction while utilizing a balance board and jumping on a trampette. Despite a number of methodological flaws in the research design (different sample sizes, differences in baseline anthropometric data, lack of standardisation of regular training programs), the results of this study suggest that specific segmental muscle control exercises may be of value in preventing and reducing LBP in gymnasts. However the implementation of the physiotherapy intervention was based on an assumption of deficits in lumbar muscle endurance and motor control across all gymnasts and did not target identified individual differences in physical characteristics.

In the study by Cusi et al (2001), two groups of rugby union players were investigated to evaluate the relationship between LBP and groin injury and an exercise intervention program for trunk strength. Sports specific risk factors for athletes participating in rugby union were not identified. Individual differences in the physical characteristics of the athlete with regards to flexibility and back strength were measured pre-season, mid-season and end-season. Injury incidence was evaluated throughout the season. Both groups underwent the same fitness and stretching program, while the intervention group also underwent three additional exercises utilizing a Swiss ball twice weekly. The additional exercises were delivered to the intervention group as a whole and not based on individual differences in physical characteristics. Results of this study reported that there were fewer lower back and/or groin injuries in the intervention group over the course of the rugby season, however these differences did not achieve statistical significance. In addition, there were no statistically significant differences in LBP prevalence or in flexibility and back strength between groups. Results of this study were limited by a small sample size and by a small number of injuries.

In a study of college rowers, Tse et al (2005) investigated the effectiveness of a trunk endurance intervention on improving the endurance of the trunk muscles. Trunk muscle endurance was assessed using an abdominal fatigue test, back extension and side flexion bridge tests. A variety of functional performance measures were also assessed (vertical jump, broad jump, shuttle run, 40 metre sprint, overhead medicine ball throw and a rowing ergometer test). Their results demonstrated the males who undertook an 8 week program targeting transverse abdominis and multifidus muscles showed selective improvements in trunk muscle endurance parameters, however no improvements were shown in functional performance tasks. Of interest, is the author's suggestion that improvements in trunk muscle endurance may be influential in preventing and reducing episodes of LBP despite no data being collected on LBP prevalence in college rowers.

Koutedakis et al (1997) investigated a sub-group of 22 female rowers who underwent a hamstring strength training program for 6-8 months. Subjects were asked to complete a questionnaire determining if they had ever had a back injury and how many missed days of training due to LBP. Subjects were tested for flexibility (sit and reach test) and lower leg strength (isokinetic dynamometry for knee flexors and extensors) pre–participation and post-participation in the training program. They concluded that 6-8 months of hamstring strength training contributed to a reduction in LBP in females, however, the lack of a control group for comparison limits the validity of these findings.

In summary there appears to be a distinct lack of literature addressing identified individual risk factors which may increase risk of LBP in specific sports. It is logical that different sports have different inherent risks unique to them, which may have to be addressed in a specific and individual manner. In addition the reported exercise interventions which have targeted more specific muscle training interventions such as in the study by Tse et al (2005) and Harringe et al (2007), have delivered these interventions in group settings, again not addressing the individual risk factors, which may have limited their findings.

(ii) specific exercise interventions

There is also a paucity of evidence base documented on the role of specific physiotherapy exercise interventions in reducing LBP prevalence and reducing pain and disability levels in athletes who experience LBP. There appears to be a lack of literature identifying the individual risk factors and the implementation of an exercise intervention specific to these risk factors. To the candidate's knowledge, there was only one other study in the literature which tested an individually applied, specific physiotherapy exercise program. This program was part of a multi dimensional intervention in a schoolgirl rowing population which showed a significant reduction in prevalence of LBP throughout a rowing season (Perich et al, 2009). The physiotherapy aspect of this intervention was based on the identification of individual risk factors and specific impairments in the individual rower. The intervention program was implemented targeting these specific deficits, with the results demonstrating a significant reduction in the prevalence of LBP in adolescent female rowers.

3.6 The development of a model for exercise intervention in sport

It is these gaps in evaluating the effect of specific physiotherapy exercise interventions on the prevalence of LBP in sporting populations which stimulated the area of investigation for this Masters thesis.

Individual impairments in spinal motor control, deficits in trunk and lower limb muscle endurance and altered relative flexibility of the hamstrings all have the potential to increase LBP risk in a high risk sport such as rowing. Individual musculoskeletal screening assessments allow for each individual to be assessed in order to identify these differences, and then a specific and targeted intervention developed to address them in a sports specific manner. It is likely that the identification of individual risk factors contributed significantly to the success of this intervention program. The aim was to address individual risk factors known to be associated with LBP in rowing, in an attempt to reduce the flexion strain on the lumbar spine. Given that previous documented studies have delivered exercise interventions in group settings these individual differences could not be catered for (Cusi et al, 2001; Nadler et al, 2001; Harringe et al,2007; Tse et al, 2005). A generic exercise program is unlikely to be able to address the individual characteristics identified in a musculoskeletal screening for the prevention of LBP and these previous studies have not based their intervention programs on the specific needs identified for each individual athlete.

Consequently, it is proposed that a model for the management of LBP in sporting populations be based upon the identification of the risk factors for specific high risk sports in combination with identifying specific risk factors associated with the physical characteristics of the individual participating in those sports. A specific exercise intervention can then be implemented based on the risk factors of the individual. It is unlikely that a generic conditioning program will be successful in managing LBP in different sporting populations with the very different patterns of spinal loading associated with different sports.

It is possible that the success of the intervention utilised in this study was associated with a number of factors.

1. A strong cognitive component involving a detailed education session, demonstration of exercises, use of mirrors for feedback with exercises, peer, coaching and physical education staff support for the intervention may have been important. It has been

suggested that exercise self-efficacy may be a mediator for physical activity behaviour changes in adolescent females (Lubans and Sylva, 2009) supporting the role of peer support and exercise self efficacy playing a significant role in the success of the intervention. Linton and Nordin (2006) determined that cognitive-behavioural group intervention provides long term health benefits, highlighting the effectiveness of cognitive interventions for the management of LBP. The role of education and self management for primary episodes of LBP is also supported by Hay et al (2005) who illustrated brief pain-management techniques may offer an alternative to manual therapy treatment.

2. The intervention addressed the habitual and sustained sitting posture of the girls during the course of the school day as well as during the rowing and ergometer sessions. As girls can spend much of their school day sitting in classrooms and in front of a computer screen, the targeting of habitual sitting postures on a daily basis may have contributed to improving postural awareness in sitting. It has been shown that slump sitting is associated with poorer back muscle endurance (O'Sullivan et al, 2006) and that usual sitting posture correlates closely with bending and lifting posture (Mitchell et al, 2008). Therefore it may be that changing habitual postures had an impact on both rowing posture and levels of back muscle endurance.

3. The intervention targeted identified deficits in motor control such as the inability to achieve an anterior pelvic tilt in rowing posture in order to reduce flexion strain on the lumbar spine. The greater degree of anterior rotation of the pelvis is thought to contribute to reduced compressive forces on the lumbar spine (Caldwell et al, 2003).

4. The intervention targeted identified deficits in back and lower limb conditioning to improve lower limb, hip flexor and back muscle endurance and strength. Evidence of back muscle fatigue has the potential to contribute to increased levels of lumbar flexion during the rowing stroke (Caldwell et al, 2003), whereas improving back muscle performance has a potential effect of reducing strain on spinal structures (Kong et al, 1996).

5. Hamstring muscle length was assessed during the musculoskeletal screening and those girls with deficits in hamstring length were prescribed specific stretches to address this issue. It has previously been reported that shortened hamstring length may limit the ability of the rower to achieve anterior tilt of the pelvis possibly resulting in increased thoracic and lumbar flexion ranges during rowing (Gadjosik et al, 1994; Reid & McNair, 2000).

6. The improvements in LBP prevalence and pain intensity change scores may also be the result of a motivated group of subjects with back pain, who self selected to undertake the intervention program.

3.7 Practical Implications of the Research

The aim of this research study was to build on the current evidence base for the efficacy of a specific physiotherapy exercise intervention for adolescent female rowers. The model for the development of such specific physiotherapy interventions must consider sports specific risk factors and individual risk factors. This study provided further evidence that individually prescribed physiotherapy exercise interventions are effective in reducing prevalence of LBP and reducing pain intensity levels in those with existing LBP, in a group of adolescent female rowers.

The results of this study, along with those of Perich et al (2009), support the role for individual exercise interventions in the management of LBP in rowers. These interventions are based on the findings of an individual musculoskeletal screening identifying the individual risk factors which may render the rower more prone to LBP. The approach of identifying individual impairments and mechanisms of LBP and subsequently targeting a specific exercise intervention within a cognitive framework is proposed to provide a better management approach in the treatment of LBP in athletic populations.

The combination of targeting individual risk factors and sports specific risk factors (such as Perich et al, 2009) necessitates an intervention program which considers both sets of risk factors in the prevention of LBP. This demands good communication between coaches, physiotherapists and physical conditioning trainers who implement such programs. Better physical conditioning may also allow coaches to extend the athlete's physiological limit although this requires further investigation. The benefits in this regard are mutual, whereby individual limitations and sports specific risks are addressed which is likely to benefit the coaches with athletes having less time spent off training through injury and the potential benefits of improved performance of the athlete.

3.8 Limitations of the study

It should be acknowledged that this field trial has a number of inherent limitations:

1. Uneven group size and low numbers of subjects in each group who completed the rowing season were due to self selection for participation and the number of withdrawals from the rowing program within the school.

2. Subjects in the experimental group paid for the physiotherapy intervention which had the potential to raise expectations for treatment success and biased the group who selected to participate based on socioeconomic grounds.

3. Due to the nature of this field based study the physiotherapy intervention was conducted as a non-randomised controlled trial. Future randomised controlled trials with random allocation of subjects to an intervention or control group within the one school may be warranted in further investigations.

4. Differences in LBP prevalence at baseline between groups had the potential to influence the study findings. A greater number of girls in the experimental group had pre-existing LBP prior to entry in to the study. It is plausible that because of this, they had a greater chance of demonstrating improvement. This taken into consideration, significant

reductions in LBP prevalence in the experimental group which was not demonstrated in the control group supports the effectiveness of this specific physiotherapy intervention.

5. In the current study, girls were requested to complete a compliance chart and bring this to follow up physiotherapy reviews. There was a poor level of adherence in returning the compliance charts. Despite the lack of adherence to completing the compliance chart, the physiotherapists were generally able to determine whether the girls had been compliant with their exercise program. The compliance of the girls in this study was not perceived to be as great as in the previous study by Perich et al (2008), which is likely due to the principal researcher of the previous study being the rowing coordinator at the school involved. Despite the lower level of perceived compliance there was still a significant reduction in LBP prevalence. A lack of compliance undertaking exercise programs has previously been reported to represent a significant problem for clinical physiotherapists in administering treatment for chronic LBP (Middleton, 2004). Patient compliance with physiotherapy cannot be assumed and rates as high as 50-66% of patients demonstrate non-compliance with exercise regimens (Middleton, 2004). A lack of adherence to exercise interventions is regarded as a substantial barrier to successful outcomes (ie. exercises don't work if you don't do them) (Moseley, 2006). It would be recommended that all girls complete a weekly training diary incorporating a compliance chart to ensure the physiotherapy intervention is undertaken. The exercise interventions, which were individually prescribed, can also form part of the weekly physical group conditioning programs at the school to enhance the social component of the intervention.

6. Secondary physical outcome measures of lower limb flexibility and lower leg endurance were collected in the experimental group only. It is therefore not known whether the changes observed in these measures were a result of the intervention or the rowing program itself. Further research would benefit from evaluating the differences in improvement in these outcomes between groups.

7. The support of the physical education and coaching staff within the school supporting the physiotherapy intervention was limited. The specific physiotherapy exercise intervention ideally requires unequivocal support from the rowing coaches and physical education staff throughout the entire rowing season, especially following completion of the physiotherapy reviews. In the previous study by Perich et al (2009) the principal researcher, Ms Debra Perich, was also the rowing coordinator and physical education staff member within the school implementing the program. As a consequence, ongoing support for the physiotherapy intervention program was provided throughout the rowing season in the previous study, which did not occur in the current study.

In spite of these limitations which represent the real life situation of clinical practice, the results of the current study reinforced the previous findings and demonstrated reduction in pain prevalence and pain intensity levels in those girls who undertook the physiotherapy intervention.

3.9 Recommendations for future research

1. Future research into the benefits of individual exercise intervention should consider individual risk factors alongside sports specific risk factors.

2. The physical conditioning program would benefit from the physiotherapist involved in the musculoskeletal screening and specific exercise intervention having input into the physical conditioning program which better complements the specific exercise intervention. In this regard, there is a greater likelihood of the girls continuing with the specific exercise intervention administered by the physiotherapists and increasing the adherence to the program.

3. A randomised controlled trial format would allow a more even distribution of subjects with LBP between groups and eliminate the process of self-selection which may have led to bias at baseline. In addition, greater sample sizes would increase the power of this study.

4. The use of a more sensitive disability / impairment scale such as the Roland-Morris disability questionnaire (Morris and Fairbank, 2000) or a sports specific functional impairment questionnaire may be beneficial in future research

5. Additional data such as spinal kinematics on the boat or on a rowing ergometer may provide further information regarding the benefits of specific exercise interventions on sitting and rowing postures in reducing the prevalence and pain intensity and disability levels in those rowers with LBP.

6. Future research into LBP in rowers would benefit from undertaking an investigation into the prevalence rates of LBP in an adolescent male population. The specific physiotherapy intervention undertaken in this study could be implemented in a schoolboy rowing population to determine if similar changes in LBP prevalence and changes in pain intensity and disability levels are repeatable.

7. The implementation of the proposed model for exercise intervention into other sporting populations would further verify the benefits of an intervention program targeting individual risk factors alongside sports specific risk factors.

8. It is acknowledged that due to the multiple statistical tests that were conducted, the likelihood of a chance finding is increased. However given the consistent pattern of the results across the different time points this is a highly unlikely basis for the findings.

Future research studies investigating the above issues will continue to provide further evidence base in the literature for specific physiotherapy exercise interventions for the management of LBP in rowers and other specific sporting populations.

3.10 Summary

The results of this field study support that the specific individually prescribed physiotherapy exercise intervention utilised in the previous study by Perich et al (2009), was associated with a reduction in the prevalence of LBP and pain intensity levels in a population of adolescent female rowers during a rowing season. Although limitations regarding the study design are acknowledged, this research contributes to the literature supporting the potential benefits of specific exercise interventions in the management of LBP in sporting populations. The proposed model for the management of LBP in sporting populations is based upon the identification of the sports specific risk factors in combination with identification of individual risk factors of the athlete. A specific exercise intervention is then able to be implemented based on these risk factors.

These results further support the need for schools providing a rowing program to implement specific physiotherapy exercise intervention programs targeting individual physical deficits to decrease the prevalence of LBP in adolescent female rowers. Further randomised controlled research is required to fully validate these results.

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Appendix

APPENDIX A

memorandum

Curtin
University of Technology

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu au

To	Associate Professor Peter O'Sullivan, Physiotherapy
From	A/Professor Stephan Millett, Executive Officer, Human Research Ethics Committee
Subject	Protocol Extension Approval HR 15/2006
Date	21 March 2007.
Copy	Dr Angus Burnett, School of Physiotherapy

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your Form B report, indicating modifications / changes, for the project *"Low Back Pain In Adolescent Female Rowers: A Multi-Disciplinary Intervention Study"*. Your application has been ***approved***, subject to the following:

1. Please advise what, if any, relationship does Body Logic have with the researchers. Please also include a sentence in the information sheets to both parents and children advising of the relationship.
2. Please simplify the language in both Parent Information Sheets. The language is too technical and should be worded similar to the Child Information sheet, whilst still retaining all the necessary information.
3. Please include the approval number HR 15/2006 on all the information sheets.

Approval for this project remains until **15-03-2008.**

Your approval number remains **HR 15/2006,** please quote this number in any further correspondence regarding this project

Thank you

pp

A/Professor Stephan Millett
Executive Officer
Human Research Ethics Committee

Curtin University of Technology

School of Physiotherapy

INDIVIDUAL INTERVENTION GROUP

Adolescent Information Sheet

Preventing Low Back Pain in Adolescent Female Rowers: A Multi-Disciplinary Intervention Study

An intervention conducted by Bodylogic Physiotherapy in conjunction with the School of Physiotherapy, Curtin University of Technology.

In 2005 some research was conducted that determined that the incidence of Low Back Pain amongst Schoolgirl Rowers was three times more prevalent than when compared to schoolgirls who do not row.
We did a follow-up study showing that a specific intervention could reduce back pain significantly across a rowing session.
Physiotherapists employed by Body Logic Physiotherapy are now undertaking further research with the School of Physiotherapy, Curtin University of Technology to find out whether we can apply this specific intervention over a number of schools and produce the same result of reducing the number of girls who suffer low back pain across the rowing season. Associate Professor Peter O'Sullivan is a specialist musculoskeletal physiotherapist with an international reputation for management of low back pain disorders. He is a partner in Body Logic Physiotherapy where he consults, and also holds a part time academic position at Curtin University where he conducts clinical research.
You will be required to attend an education session about low back pain and injury. This session will include factors that cause low back pain and things that you can do to lessen the possibility of getting it.
You will then undergo a back screening by an experienced Physiotherapist that will identify things about your back posture when sitting standing, lifting and rowing that may increase your risk of low back pain when rowing. This approach is widely used when kids of your age start elite rowing programs. You will be given specific posture exercises for you to do at home. It is important that you do these if you agree to participate in this intervention as they are designed to help reduce your risk of back pain rowing.
Also you be doing strength and conditioning sessions during rowing training, that are designed to increase your lower limb endurance and back muscle endurance.

When you are screened you will need to wear your shorts and a half top or sports bra. A bather top would also be fine. This will help the physiotherapist do a thorough screening and design a program for you.

What else will be measured?

A series of questionnaires have been developed that will investigate the prevalence of back pain, levels of pain and disability that you are experiencing.

What is involved and how long will it take?
You will be required to complete 3 questionnaires that will take approximately 15 minutes of your time and these will be given to you at 4 times during the season. While you undergo the screening you will be able to ask as many questions as you like. You can pull out at any time without having to give a reason and without any penalties.

How will this information be used?
We'll see if the number of you experiencing LBP will decrease when a special training program is put in place. We'll provide a report for your school Principal and publish the results in scientific journals (magazines) but don't worry, no names will be given and no one but the researchers will know you've been a part of the research. We want to decrease the amount of pain experienced whilst rowing and make the sport more enjoyable for all of you who participate.

If you have any questions you are welcome to ring us, or ask your Mum, Dad or Caregiver to.

Ring:

Alison Thorpe (93817940)
Body Logic Physiotherapy, Shenton Park

Assoc Prof Peter O'Sullivan (92663629)
School of Physiotherapy, Curtin University of Technology
Body Logic Physiotherapy

Dr Angus Burnett (92663662)
Research Fellow School of Physiotherapy, Curtin University of Technology.

Human Research Ethics Committee approval number HR15/2006

INDIVIDUAL INTERVENTION GROUP
Parent Information Sheet

Preventing Low Back Pain in Adolescent Female Rowers: A Multi-Disciplinary Intervention Study

An intervention study conducted by Body Logic Physiotherapy in conjunction with the School of Physiotherapy, University of Technology

PURPOSE

Rowing is one of the largest participant sports of the Independent Girls' Schools' Sports Association (IGSSA) in Western Australia with approximately 400 participants. Research funded by IGSSA and conducted in the 2005 and 2006 rowing seasons by Ms Deb Perich through the School of Physiotherapy, Curtin University of Technology has shown that school girl rowers had an incidence of low back pain three times greater than school girls who do not row. It is known that the experience of low back pain is the most predictive factor for future low back pain. Ms Perich also found deficits in muscle strength and spinal posture in rowers with back pain.

A follow-up study funded by IGSSA and conducted by the School of Physiotherapy, Curtin University of Technology in conjunction with Body Logic Physiotherapy, Shenton Park, showed that a specific intervention program could reduce back pain significantly across the rowing season. The rowing training program at Perth College was modified from 2005 to include an individual musculoskeletal screening by experienced physiotherapists, postural education and specific conditioning exercises.

Following this, IGSSA have asked Body Logic Physiotherapy to offer this intervention to other rowing schools. Physiotherapists employed by Body Logic Physiotherapy are undertaking further research in conjunction with the School of Physiotherapy, Curtin University of Technology, to evaluate whether we can apply this intervention over a number of schools with the same result of reducing low back pain and disability in adolescent girl rowers. Associate Professor Peter O'Sullivan is a specialist musculoskeletal physiotherapist with an international reputation for management of low back pain disorders. He is a partner in Body Logic Physiotherapy where he consults, and also holds a part time academic position at Curtin University where he conducts clinical research.

Your daughters school has elected to adopt the individual based intervention.
At your daughter's school the rowing training program has been significantly modified from 2006 to include spinal education, an individual musculoskeletal screening, postural education and spinal conditioning program and specific conditioning exercises.

HOW? What do I have to do?

Participation in the intervention is voluntary. Initially your daughter will also undergo a LBP education session explaining the mechanics of the spine and injury risk to the low back with regards to rowing.

Next all girls will undergo a musculoskeletal screening by an experienced physiotherapist to identify factors that may be related to back injury. This will involve assessing spinal flexibility and postural control in sitting, standing, lifting, squatting and rowing. This is widely considered as a best practice approach. The girls will then be given a specifically tailored exercise program. There will be 2 follow-up sessions one week and three weeks after the screening to reinforce and correct the exercise program. For the screening and follow-ups your daughter will need to wear her shorts and a half top or sports bra. A bather top would also be fine.

In addition, she will participate in a strength and conditioning program which will be specifically designed to increase lower limb and back muscle endurance, factors that were clearly identified as being related to the presence of LBP in our research conducted in 2005.

The cost to you will be $215 (consistent with normal fees for an initial and two follow-up physiotherapy appointments). This is claimable across the three sessions if you have the appropriate ancillary health cover and if your daughter currently experiences LBP.

If your daughter participates in the research she will complete a series of questionnaires that will take approximately 15 minutes to complete and will be issued on four occasions during the rowing season (week 3, week 12, week 21 and 10 weeks post season). These questionnaires will include a general questionnaire to determine if your daughter experiences low back pain whilst rowing, as well as a questionnaire measuring the level of pain, and restrictions to daily activity related to the pain. These questionnaires will be used to determine the effect of the intervention.
There are no risks associated with participation in this research.

The benefit of participating in this intervention is that your child will benefit by receiving education and exercises demonstrated to decrease the prevalence of LBP amongst female adolescent rowers across a rowing season. Information about the findings of this study and recommendations will be made available to you via your school at the completion of the study.

Will my child's information be kept confidential?
We are collecting your daughter's name so we can recognize her to match the four questionnaires that she completes throughout the season. All other information collected will be anonymous.

Your child will be allocated an identification number that will remain confidential to the investigators and the intervention supervisor. All recorded data will be entered in a Spreadsheet excel program, on a Curtin School of Physiotherapy computer using your identification number only, no names will be used. Access to the stored data will be restricted by a password known only by the investigators and the project supervisor. All data collected and consent forms will be stored safely in a locked cupboard at the Curtin School of Physiotherapy and Body Logic Physiotherapy.

Appendix C

Ethical approval has been obtained for this study from the Human Research Ethics Committee of Curtin University of Technology (approval number HR 15/2006). It has also been approved by your school Principal.

How will this information be used?
The information will be analysed to determine if a multi-disciplinary intervention program can be applied across a number of schools in order to decrease the number of girls experiencing low back pain. It will provide important information to the Principals of the IGSSA schools in determining safe training and screening methods to minimize the occurrence of low back in adolescent female rowers.
The results of the study the study will be published in international scientific journals. No published reports will have information that identifies any of the individual subjects.
A report will also be presented to your school Principal when we have finished the study.
We would like you to feel free to ask any questions you may have about any aspect of the study. It is important that you understand why we are asking you to allow your child to participate in this study.

The point of contact in this regard is:
Alison Thorpe (Sports Physiotherapist), Body Logic Physiotherapy, Shenton Park.

We would like to assure you that all information we collect is strictly confidential. Curtin University and its researchers, and Body Logic Physiotherapy are bound by the Privacy Act 1988 and abides by this at all times.

If you have any concerns or complaints regarding the way this study is being conducted you can direct enquires to the Secretary of the Human Research Ethics Committee Curtin University, Ms Linda Teasedale on 08 9266 2784.

Thank you once again for considering this important research.

Alison Thorpe (93817940)
Body Logic Physiotherapy, Shenton Park

Assoc Prof Peter O'Sullivan (92663629)
School of Physiotherapy, Curtin University of Technology
Body Logic Physiotherapy

Dr Angus Burnett (92663662)
Research Fellow School of Physiotherapy, Curtin University of Technology.

Curtin
University of Technology

School of Physiotherapy

Document of Informed Consent

Low Back Pain in Adolescent Female Rowers: A Multi-Disciplinary Intervention Study

I ____ have read all of the information contained on this sheet, and have discussed it with my daughter, and have had all questions relating to the study answered to my satisfaction.

I agree for my daughter to participate in this study and understand that she is free to withdraw at any time, for any reason without prejudice.

I agree that the research data obtained from this study may be published. I understand that my daughter will not be identifiable in any way as a process of this study.

Name of participant:____

Parent/guardian signature:____________________________ Date:__________

Investigator:______________________________________ Date:__________

Appendix E

2007 Rowing Season
Physiotherapy Intervention Study

Name:______________________________________

School:_____________________________________

Year:_______________________________________

We are interested in the reasons you have withdraw from rowing during the 2007 rowing season. Could you please tick the most appropriate box?

What is the reason you have withdrawn from rowing?

1. Low back pain ☐
2. Heavy training loads ☐
3. Lack of time ☐
4. Didn't like rowing ☐
5. Other_____________________ ☐

If you have withdrawn as a result of low back pain please answer the following questions.

1. When did your low back pain start?

   ☐

2. Did you seek treatment? What sort of treatment?

   ☐

3. Did you benefit from treatment?

   ☐

4. At what stage of the season did you withdraw?

   ☐

5. Would you row in 2008?

   ☐

Thank you for taking the time to fill out this questionnaire.

Alison Thorpe

Body Logic Physiotherapy

APPENDIX F

NAME	SCHOOL	YEAR	DOB		Initial	F/U 1	F/U 2
				Dates/PT			
History							
Past History							
Current LBP							
Agg Factors							
Ease Factors							
Current Training Load	Water sessions	per wk					
	Gym sessions	per wk					
	Ergo	per wk					
	Other sports						
Previous Episodes of LBP	Date						
	Intervention	Yes	No				
	Treatment received						
	Number of visits						
	Medication						
	Activity impairment						

	TESTS							Initial	F/U 1	F/U 2
	MUSCLE LENGTH						Dates/PT			
1	**SLR**		< 70	70 - 90	> 90					
2	**Hip Flexion**		< 90	90 - 120	> 120					
3	**Psoas**		.+10	.=0	.-10					
4	**Sit and Reach**	(hold 3 secs)		cms						
	thoracic		neutral	flexed	extended					
	lumbar		neutral	flexed	extended					
5	**DF Lunge**			cms						
	STANDING POSTURE		Sway	Increased ant tilt		Flat lordosis				
	STANDING Lx ROM		Axis of hinge							
	flexion		Lumbar	Thoracic	Hip movt					
	extension		Lumbar	Thoracic	Hip movt					
	SITTING POSTURE									
	Usual		neutral	slump	Tx upright	hyperlordotic				
	Upright		lumbo-pelvic		thoracic					
	Re-position correct posture		proprioception		YES	Needs prompting	NO			
	SITTING KNEE LIFTS		maintains Lx neutral		Lx flex	Lx ext	Tx ext			
	SIT AND TRUNK FLEX		maintains Lx neutral		Lx flex	Lx ext	Tx ext			
	SIT TO STAND		maintains Lx neutral		Lx flex	Lx ext	Tx ext			
	SQUAT		maintains Lx neutral		Lx flex	Lx ext	Tx ext	IR hips		
	thoracic reach in squat		maintains Lx neutral		Lx flex	Lx ext	Tx ext			
	TIMED SQUAT TEST			seconds	(90/90 hip/knee)					
	SINGLE LEG SQUAT		trendelenburg		poor post stab	lat wt shift				
	ROW POSITION		maintains Lx neutral		Lx flex	Lx ext	Tx ext			
	DOUBLE HIP FLEXION		maintain Lx neutral		Lx flex	Lx ext	Tx ext			
	(in row position)									
	ERGO		dominant leg drive		Tx ext	excess Lx flex				

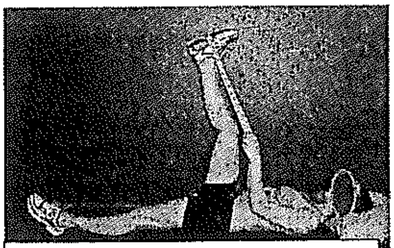
INDIVIDUAL EXERCISE PRESCRIPTION					Please tick which exercises have been prescribed to individual girls								
ROWING FLEXIBILITY					INITIAL		1ST F/U		2ND F/U				
				Date									
1	Calf stretch												
2	Bent knee calf stretch												
3	Hamstring stretch												
4	Sitting hamstring stretch												
5	Standing hamstring stretch												
6	Gluteal stretch												
7	Sitting gluteal stretch												
8	Piriformis stretch												
9	Hip flexor stretch												
10	Spinal extensor stretch												
ROWING EXERCISES													
1	Correct sitting posture												
2	Four point kneel												
3	Pelvic tilts in lying												
4	Sitting - move from pelvis												
5	Sit and forward lean												
6	Half squat												
7	Squat with upper trunk bend												
8	Sitting knee lifts												
9	Wall squat												
10	Kneeling squat												
11	Row position												

ROWING FLEXIBILITY

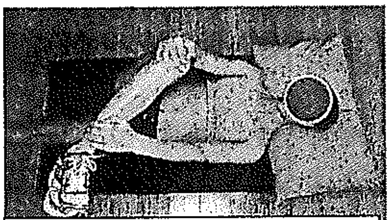
The rowing action involves significant levels of bending from the lower back.
This repetitive bending can increase the risk of low back pain.
Back pain is the most common injury to rowers. There are many factors that will help you reduce the risk of back pain and these will be explained by the physiotherapist.
It is important to understand and do the exercises daily.
STRETCHES : Repeat stretch x 3. Hold 30 seconds.

Calf stretch

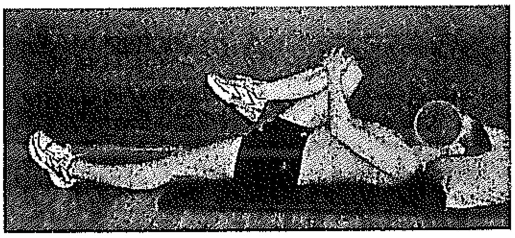
Bent knee calf stretch



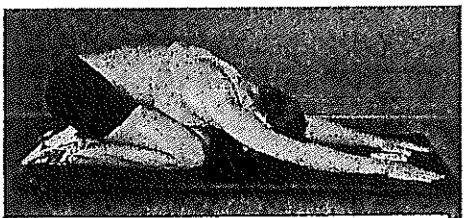
Hamstring stretch



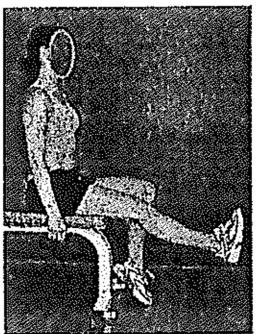
Piriformis stretch



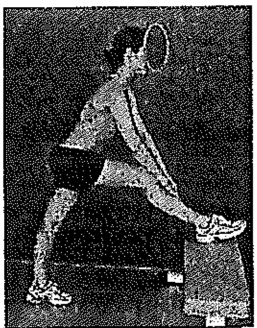
Gluteal stretch



Spinal extensor stretch

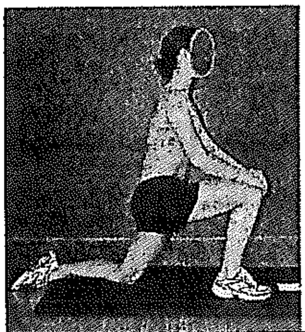


Sitting hamstring stretch



Standing hamstring stretch

Sitting gluteal stretch



Hip flexor stretch

BODY LOGIC PHYSIOTHERAPY 9381 7940

ROWING EXERCISES

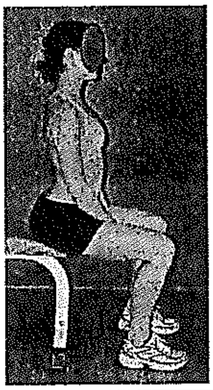
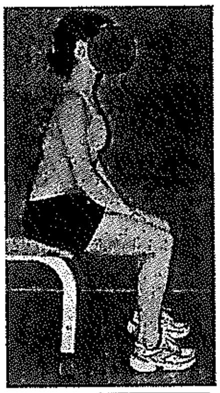
Rowing without back pain requires:

* excellent independent control of the lower and upper back
* excellent strength and endurance of the legs and back

How you sit at school affects how you row – correct sitting posture throughout the day is important to enable you to learn to row safely

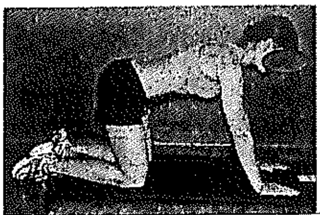
When doing exercises your technique and spinal position is critical – use a mirror if uncertain. Exercises should not cause back pain – but muscle soreness is good.

If you have pain, first check technique - if it persists contact the physiotherapist

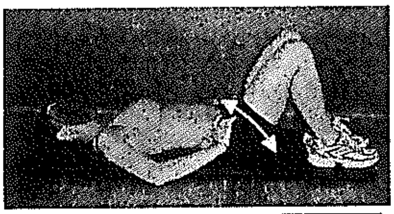




Incorrect sitting posture

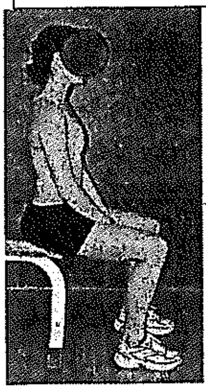
Correct sitting posture



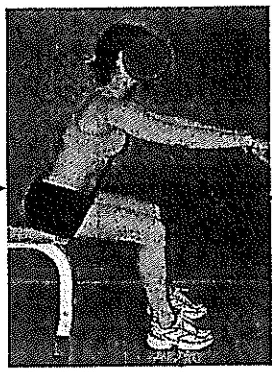
Four point kneel – rotate tailbone up to roof



Pelvic tilts in lying



Sitting – move from pelvis



Sit and forward lean

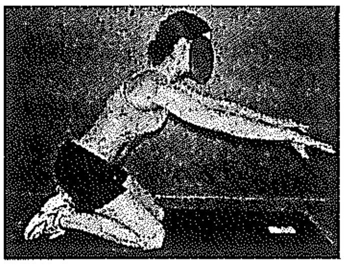
Half squat

Squat with upper trunk bend

Sitting knee lifts

Wall squat

Row position



Kneeling squat

APPENDIX J

COMPLIANCE CHART

NAME SCHOOL YEAR

EXERCISES — Please date and record your exercises on a daily basis and mark with a tick

	EXERCISES	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
	Flexibility																					
1																						
2																						
3																						
4																						
	Strength																					
1																						
2																						
3																						
4																						
5																						
6																						

APPENDIX K

Schoolgirls' Rowing Association of Western Australia
Questionnaire for participants 2007

The Schoolgirls' rowing population are invited to complete the questionnaire below as a follow up study from the research conducted during the 2005 Rowing season.

Thankyou for taking the time to complete the following questions.

Name: ____________________

School: ____________________

Year (please tick)

Yr 9	☐
Yr 10	☐
Yr 11	☐
Yr 12	☐

Rowing Experience (please tick)

First Season	☐
Second Season	☐
Third Season	☐
Fourth Season	☐
> Four Seasons	☐

Date of Birth: ____________________

Height (cms): ____________________

Weight (kgs): ____________________

Other Sporting interests ____________________

1. Have you ever experienced lower back Pain? Yes ☐ No ☐

If no, skip to Question 4 on page 3

2. If yes, do you currently experience lower back pain whilst Rowing? Yes ☐ No ☐

3. When do you first remember experiencing LBP and how did it come about?

____

____

____

____

____

We are interested in knowing which activities bring on your back pain. Please place a tick in any of the boxes if you feel low back pain when doing any of the following activities:

☐ Lifting a rowing shell. Eg. On and off the water, or loading the trailer

☐ Sweep rowing (in an Eight)

☐ Rowing in a Quadruple Scull

☐ Rowing in a Single Scull

☐ Ergometer Rowing

☐ Long rows in a training session

☐ Other, please specify

____

____

____

4. Please indicate by ticking the boat(s) you race in regularly.	Sweep Eight	☐
	Quad Scull	☐
	Individual Scull	☐
5. On average how many hours per week in rowing related training?	On Water	☐
	On land	☐
6. Of the sessions on water, please rank from most frequent to least frequent the boat you train in (1 = most frequent)	Sweep Eight	☐
	Quad Scull	☐
	Individual Scull	☐
7. On average how many hours per week at The moment do you spend doing physical Activity other than rowing?	0 hours	☐
	Less than 5 hours	☐
	Greater than 5 hours	☐

APPENDIX L

Rowing Physiotherapy Intervention Program
Mid Season Questionnaire

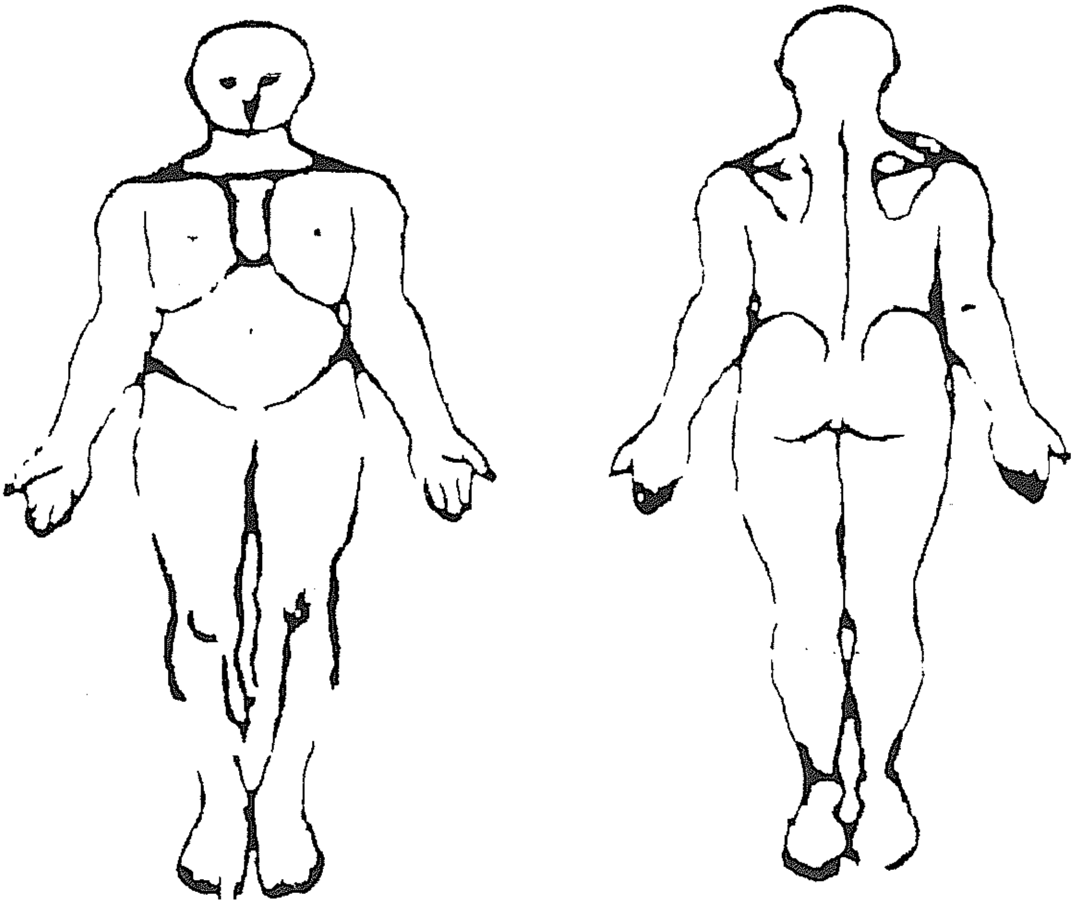
Name

School

Year

Date

Please mark on the body chart below any areas where you <u>currently</u> experience back pain.



APPENDIX M

Please put a mark on the scale to show how bad your ***usual*** pain has been ***whilst rowing.***

NO PAIN	|______________________________|	WORST POSSIBLE PAIN

From Ogon et al. (1996). Chronic low back pain measurement with visual analogue scales in different settings. Pain, 64, 425-428.

Please put a mark on the scale to show how bad your pain ***is now.***

NO PAIN	|______________________________|	WORST POSSIBLE PAIN

From Ogon et al. (1996). Chronic low back pain measurement with visual analogue scales in different settings. Pain, 64, 425-428.

APPENDIX N

Modified Oswestry Questionnaire

This questionnaire has been designed to provide information on how your low back pain has affected your ability to manage in everyday life. Please answer every section, and mark in each section only the ***one box*** that applies to you. We realise you may consider that two of the statements in any one section relate to you, but please ***just mark the box which closely describes your problem***

Section 1 – Pain Intensity

- ☐ I can tolerate the pain I have without having to use pain killers
- ☐ The pain is bad but I manage without taking pain killers
- ☐ Pain killers give complete relief from pain
- ☐ Pain killers give moderate relief from pain
- ☐ Pain killers have no effect on the pain and I do not use them

Section 2 – Personal Care (Showering, Dressing etc)

- ☐ I can look after myself normally without causing extra pain
- ☐ I can look after myself normally but it causes extra pain
- ☐ It is painful to look after myself and I am slow and careful
- ☐ I need help every day in most aspects of self care
- ☐ I do not get dressed, wash with difficulty and stay in bed

Section 3 – Lifting

- ☐ I can lift heavy weights without extra pain
- ☐ I can lift heavy weights but it gives extra pain
- ☐ Pain prevents me from lifting heavy weight off the floor, but I can manage if they are conveniently positioned, eg on a table
- ☐ Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned
- ☐ I cannot lift or carry anything at all

Section 4 – Walking

- ☐ Pain does not prevent me walking any distance
- ☐ Pain prevents me walking more than 800m
- ☐ Pain prevents me walking more than 400m
- ☐ Pain prevents me walking more than 200m
- ☐ I can only walk using a stick or crutches
- ☐ I am in bed most of the time and have to crawl to the toilet

Section 5 – Sitting

- ☐ I can sit in any chair as long as I like
- ☐ I can only sit in my favourite chair as long as I like
- ☐ Pain prevents me from sitting more than 1 hour
- ☐ Pain prevents me from sitting more than ½ hour
- ☐ Pain prevents me from sitting more than 10 mins
- ☐ Pain prevents me from sitting at all

Comments

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Section 6 – Standing

- ☐ I can stand as long as I want without extra pain
- ☐ I can stand as long as I want but it gives me extra pain
- ☐ Pain prevents me from standing for more than 1 hour
- ☐ Pain prevents me from standing for more than 30 mins
- ☐ Pain prevents me from standing for more than 10 mins
- ☐ Pain prevents me from standing at all

Section 7 – Sleeping

- ☐ Pain does not prevent me from sleeping well
- ☐ I can sleep well only by using tablets
- ☐ Even when I take tablets I have less than six hours sleep
- ☐ Even when I take tablets I have less than four hours sleep
- ☐ Even when I take tablets I have less than two hours sleep
- ☐ Pain prevents me from sleeping at all

Section 8 – Social Life

- ☐ My social life is normal and gives me no extra pain
- ☐ My social life is normal but increases the degree of pain
- ☐ Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g. dancing , sport
- ☐ Pain has restricted my social life to home
- ☐ I have no social life because of pain

Section 9 – Travelling

- ☐ I can travel anywhere without extra pain.
- ☐ I can travel anywhere but it gives me extra pain
- ☐ Pain is bad but I manage journeys over two hours
- ☐ Pain restricts me to journeys of less than one hour
- ☐ Pain restricts me to short necessary journeys under 30 minutes
- ☐ Pain prevents me from travelling except to the doctor or hospital

APPENDIX O

MID SEASON QUESTIONNAIRE FOR ADOLESCENT FEMALE ROWING STUDY

Please answer all questions on this questionnaire. Thank you for helping us to identify factors which contribute to back pain in high school girls who participate in rowing.

Name ________________________________

Year ________________________________

School ________________________________

Have you experienced any back pain since the commencement of the rowing season?

YES NO

Have you missed any training sessions due to back pain?

YES Number of sessions missed ____________________

NO

Have you required any medication/tablets for back pain?

YES Type of treatment ____________________

NO

Have you received treatment other than the physiotherapy intervention program conducted at your school?

YES Type of treatment ____________________

NO

Have you had to modify any of your daily activities due to back pain?

YES Which activities have been affected? ________________

____

NO

APPENDIX P

END OF SEASON QUESTIONNAIRE FOR ADOLESCENT FEMALE ROWING STUDY

Please answer all questions on this questionnaire. Thank you for helping us to identify factors which contribute to back pain in high school girls who participate in rowing.

Name ____

Year ____

School ____

Have you experienced any back pain since the commencement of the rowing season?

YES NO

Have you missed any training sessions due to back pain?

YES Number of sessions missed ____________________

NO

Have you required any medication/tablets for back pain?

YES Type of treatment ________________________

NO

Have you received treatment other than the physiotherapy intervention program conducted at your school?

YES Type of treatment ________________________

NO

Have you had to modify any of your daily activities due to back pain?

YES Which activities have been affected? ______________

____

NO

APPENDIX Q

POST SEASON QUESTIONNAIRE FOR ADOLESCENT FEMALE ROWING STUDY

Please answer all questions on this questionnaire. Thank you for helping us to identify factors which contribute to back pain in high school girls who participate in rowing.

Name ______________________________

Year ______________________________

School ______________________________

Have you experienced any back pain since the rowing season has finished?

YES NO

Have you required any medication/tablets for back pain?

YES Type of treatment ____________________

NO

Have you received any treatment for back pain since the rowing season has finished?

YES Type of treatment ____________________

NO

Have you had to modify any of your daily activities due to back pain?

YES Which activities have been affected? ____________

____

NO

Please fill in the following questionnaires only if you have experienced back pain since the completion of the rowing season.

Thank you
Alison Thorpe