CHAPTER 3

METHODOLOGY

3.1 Introduction

The focus of the present study was to test low back muscle strength as well as psychological factors in subjects with chronic low back pain, place them on two exercise intervention programmes (conservative or progressive-aggressive programmes) for 12 weeks, and re-evaluate them according to the original protocol. Psychological factors were also tested at week 4 and week 8. All of the testing was performed before and after the intervention period. Test procedures were identical on both occasions and performed by the same examiner.

3.2 Participants

Selection for this study was done by randomisation. Advertisements were placed in local newspapers as well as on local radio. Referrals by general practitioners were also used. Potential subjects were then contacted by telephone and sent all of the required paperwork by e-mail or fax. Inclusion and exclusion criteria were as follows:

- Inclusion criteria
    - Both male and female subjects
    - Between the ages of 20-55
    - Suffering from back pain for at least 12 weeks
    - No neurological symptoms
    - With or without radiating symptoms in the legs (included as long as there were no neurological symptoms)
    - Score of at least 35 of the visual analogue scale for pain

- Exclusion criteria
    - Previous spinal surgery
    - Spinal pathology and discogenic disease
    - Any ‘red flag’ symptoms
    - Current pregnancy
    - On-going disability and injury compensation cases

- Exercise therapy modality treatment within the last six months
- Body mass index (BMI kg/m^2) of over 40 (severely overweight)

All subjects had to complete a screening questionnaire to identify any potential ‘red flag’ diseases. The questionnaires were then screened by a medical specialist (rheumatologist) to try and identify any possible warning signs. Subjects were given a copy of the questionnaire to read in advance, and asked to sign the document and state that they understood all of the risks and rewards involved in the study.

All subjects also had to complete and sign an informed consent form that was approved by the University of Pretoria’s Faculty of Humanities as well as the Faculty of Health Science.

All of the testing procedures as well as the 12 week intervention programme were explained in detail to the subjects during the first meeting.

A random table of numbers was used, as found in Thomas and Nelson (2001). Each subject was allocated a number, which also assured anonymity when the data was analysed. They were then randomly allocated to either the conservative exercise group or the progressive-aggressive exercise group.

3.2.1 History of the Subjects

In total 45 subjects were recruited for the study and randomly assigned to either the conservative exercise group (n = 20) or the progressive-aggressive exercise group (n = 25). However, 13 dropped out of the study before they were screened. Of the 13 drop-out figure, one subject’s symptoms were too severe due to an advanced spondolylisthesis, three lived too far away and could not undertake the regular journey, one subject’s spouse fell severely ill, one subject had to go back to her home country, one fell down a flight of stairs and was recommended by the medical doctor to not do any exercise for at least six months and the rest (six subjects) dropped out due to work commitments/problems.

Of the subjects that remained 32 were screened and started on the exercise programmes. During the course of the study six subjects dropped out of the study before they had completed four weeks (three had too many work commitments, one had too many family commitments, one emigrated and one lost interest). Four subjects dropped out after completing four weeks, but not reaching eight weeks (one emigrated, one had transport problems, two had work problems). Another subject dropped out after completing eight weeks but not getting to 12 weeks due to transport problems, while 21 subjects completed the full 12 week intervention programme (n = 10 in the conservative exercise group and 11 in the progressive-aggressive group). Only the subjects who were screened will have their data used in the study.

3.2.1.1 The Use of Low Numbers in the Present Study

The use of low numbers in similar studies is not uncommon. Subjects with low back pain are difficult to recruit for studies involving exercise therapies. This may be because of a number of factors. Greater numbers are not always possible if subjects are either not inpatient-based or outpatient-based.

During a review of the literature by Moreau *et al.* (2001) concerning the testing of the low back extensor muscles it was reported that studies using 10 subjects or less showed some of the best reliability results, although some would argue that the sample size is too small to draw any conclusions from it.

Cleland *et al.* (2005) reported that a sample size of 15 subjects per group provides greater than 80% power to detect both statistically significant and clinically meaningful differences between groups. The researchers from that study screened 117 subjects and 81 subjects (69%) did not satisfy the inclusion and exclusion criteria for participation. Six (5%) refused participation, which, as they stated, was due to very strict inclusion and exclusion criteria (Cleland *et al.*, 2005). They only used 30 participants in their study. It is not mentioned how many subjects completed the study and it is thus assumed that 30 completed the study.

Radebold *et al.* (2000) used 17 healthy subjects and 17 subjects with chronic low back pain in a study to determine if subjects with chronic low back pain reacted differently to healthy subjects when a sudden load is released. They hypothesised that delayed muscle response and altered muscle recruitment patterns would emerge in subjects with chronic low back pain (Radebold *et al.*, 2000). It may be argued that only 17 low back patients participated in their study and there was no timeframe involved; subjects participated in a once-off test.

Similarly, Hodges and Richardson (1996) used 30 subjects for a motor control experiment. Of these subjects 15 were healthy and 15 suffered from chronic low back pain. Their motivation for subject selection was based on strict clinical criteria of chronicity and severity. They argued these to be necessary because of the difficulty in obtaining a homogenous subject group based on current investigative techniques. These techniques are unable to identify a definitive cause for back pain in the majority of subjects (Hodges & Richardson, 1996).

Richardson *et al.* (2002) also used a small population group of healthy subjects for a once-off measurement test. In total they used 13 subjects without a history of low back pain and attempted to gain objective measurement values regarding sacroiliac joint mechanics and its contribution to low back pain management (Richardson *et al.*, 2002).

O'Sullivan *et al.* (2003) used a cross-sectional observational design, which included 15 healthy subjects and 15 subjects with a history of chronic low back pain lasting up to three months. Again the investigators attempted to gather objective data using a small population group.

Also, Moseley *et al.* (2002) used eight subjects and deep muscle electromyographic instruments to measure muscle activation in healthy subjects.

Kankaanpää *et al.* (2005) used 12 healthy subjects and 17 subjects with chronic low back pain to measure muscle fatigue ratios during dynamic exercise. This study used objective data as well as a small sample population group. Their criteria for subject selection were similar to those of the present study. Subjects who had been suffering from low back pain for longer than three months, had not undergone any spinal surgery and suffered from no 'red flag' conditions (nerve root entrapment, spinal cord compression, tumours, osteoporosis, recent spinal fracture, cardiovascular disease, metabolic disease or acute infections) were used during the study (Kankaanpää *et al.*, 2005).

Linemen *et al.* (2003) used 20 subjects selected for surgery due to disc herniation and measured their muscle repositioning ability. The researchers compared them to healthy controls. Both studies used small sample groups, although the characteristics of the subjects were different in both studies. This shows the difficulty in recruiting subjects with homogenous characteristics for low back pain studies.

Hasegawa *et al.* (2008) used 22 patients in a study to measure lumbar segmental instability with an intraoperative measurement system. This study used a small sample. However, the inclusion criteria were very strict. The study was also very labour intensive, as the subjects were measured by means of radiological imaging as well as being measured surgically.

In many of these studies an experimental group was compared to a control group that consisted of healthy subjects. It has to be noted that both groups used in the present study were homogenous and all suffering from chronic low back pain.

Arokoski *et al.* (2004) used a small population group consisting of a total of nine subjects. Their study involved a 12 week exercise intervention programme comprising four to six exercise sessions per week over the 12 week period, based on an outpatient basis. Their subject population group was very similar to the population group used in the present study. Specific causes of back pain, previous spinal surgery, any 'red flag' condition as well as having suffered from back pain for longer than three months were excluded from the study.

The present study used the same selection criteria for selecting subjects like many of the studies mentioned (Arokoski *et al.,* 2004; Petersen *et al.*, 2002). It also used subjects with chronic low back pain in both the control and experimental groups. Also, the study was very labour intensive, both from the researcher's point of view as well as the subjects' participation. Subjects had to commit to the study for 12 weeks. Work commitments became an issue for many participants. It is because of this that the present study will identify a new term: *Full working capacity adults* (FWCA). All subjects participating in the study were working full-time, which included anything from 8-12 hours per day. Travel time to work was also considered. The participating subjects were thus neither inpatient-based nor outpatient-based. This concept will be dealt with further in the discussion chapter.

3.3 Methods and Materials

The methods and materials mentioned below were used.

3.3.1 Medical Screening

All subjects included in the study had to complete a screening questionnaire, which was designed purely to identify potential 'red flag' conditions or anything that could exclude them from the study. After completion the screening questionnaires were reviewed by a practicing rheumatologist and senior lecturer at the University of Pretoria in the department Sport Medicine. Of all those who were screened, none presented with any dangerous symptoms that would exclude them from participating in the study.

3.3.2 Study Design

The design of the study will be a pre-test/post-test randomised group design. The major advantage of this type of study is that the amount of change produced by the treatment can be measured by measuring the amount of improvement in the experimental group compared to the control group (Thomas & Nelson, 2001). The study was designed to be a pre-test/post-test randomized group design, and has the advantage of being able to compare the control and experimental groups in order to measure the effectiveness of the treatment by observing the amount of change produced by the treatment (Thomas & Nelson, 2001).

In this type of research design subjects are randomly allocated to their respective groups with both groups receiving a pre-test as well as a post-test (Thomas & Nelson, 2001). This type of research has been acknowledged as being the most scientific of all research designs (Thomas & Nelson, 2001). Both the control and experimental groups were measured at pre-test as well as post-test, after they are randomly allocated to their predesigned groups. Acknowledgement has recognized this type of research design as being one of the most scientific (Thomas & Nelson, 2001).

By default this design threatens internal validity through testing (the effect of one test on subsequent administration of the same test, i.e. a learning effect) but this threat is controlled by comparison between the two groups (Thomas & Nelson, 2001). Age-gender matched controls will also be applied in the design. This type of design can threaten internal validity through a learning effect when the effect of one test on following administration of the same test occurs. However, comparison between the two groups controls this threat. (Thomas & Nelson, 2001). Age-gender matched controls will also be applied in the design.

3.3.3 Questionnaires

Several questionnaires were used in the study. All of the questionnaires were completed by the subjects at pre-test, four weeks, eight weeks and at the end of the study at 12 weeks. All of the selected questionnaires are used extensively in low back pain and physical therapy studies, because they are all valid, reliable, repeatable, sensitive to change and they correlate well with other instruments (Linton *et al.*, 2005; Heymans *et al.*, 2006; Kääpä *et al.*, 2006; Goldby *et al.*, 2006). Questionnaires were selected that would measure self-reported pain, levels of disability, levels of kinesphobia and fear avoidance beliefs.

3.3.3.1 Pain and Disability

The following questionnaires were used to measure levels of pain and disability:

3.3.3.1.1 The Visual Analogue Scale (VAS) for Pain Measurement

The VAS consists of a single 100 mm line across the surface of a page. On the left side of the line no pain is indicated, while maximal amount of pain is indicated on the right hand side of the line. Subjects had to indicate how they would rate their own pain by indicating it on the scale (Ostelo & De Vet, 2005).

A score is presented out of a 100 being maximal. The intensity of low back pain is measured to determine the quantitative estimate of how severe the patient perceives their back pain measured by this subjective scale (Kankaanpää *et al.*, 2005; Ostelo

&De Vet, 2005). This instrument has a high test-retest reliability of r>0.95, has high criterion related validity with established instruments and is well suited to measure pain intensity (Wewers & Lowe, 1990).

3.3.3.1.2 Oswestry Disability Index (ODI)

The impact of low back pain on daily activities is measured by the Oswestry Disability Index (Fairbank & Davies, 1980). It is used to measure non-malignant spinal disorders and is one of the most common used self-administrated questionnaires (Turk & Marcus, 1994; Doleys *et al.*, 1997; Deyo *et al.*, 1998; Carreon *et al.*, 2008; Mehra *et al.*, 2008). The ODI is also used to measure condition-specific outcomes (Fairbank & Pynsent, 2000).

Low back pain included disability and limitations in daily tasks and leisure time activity is included in a 10 section questionnaire (Fairbank & Davies, 1980; Ostelo & De Vet, 2005; Mehra *et al.*, 2008). Each section has a score of 0-5 with 0 representing no disability and 5 representing maximal disability (Ostelo & De Vet, 2005; Mehra *et al.*, 2008).

Totals for the questionnaire is determined by means of a percentage score, where the index is calculated by dividing the summed scores by the total possible score, and is then multiplied by 100 (Ostelo & De Vet, 2005; Mehra *et al.*, 2008). The total score is reduced by 5 for every question that is not answered, and the highest scoring statement is recorded when more than one answer is marked (Mehra *et al.*, 2008).

Mehra *et al.* (2008) reported that the question frequently not answered related to the subject's sex life and this result was also found in the present study. The Oswestry Disability Index has been found to be reliable, valid and sensitive to change (Fisher & Johnston, 1997).

3.3.3.1.3 Functional Rating Index (FRI)

According to Feise & Menke (2001) the Functional Rating Index is an instrument purposely designed to quantitatively measure the subjective perception of function and pain of the spinal musculoskeletal system in a clinical setting. In particular, it evaluates the patient's subjective report of his/her ability to perform dynamic movements of the neck and back and/or withstand static postures.

It was developed to provide an assessment instrument that has clinical value (i.e., easy and fast for both the patient and the health care team) yet quantifies the patient's current state of pain and dysfunction in a reliable and valid manner for spinal conditions (Feise & Menke, 2001).

According to Feise and Menke (2001) the FRI instrument contains 10 items that assess both pain and function of the spine and its musculoskeletal system. Of these 10 items, 8 refer to activities of daily living that might be adversely affected by a spinal condition, and 2 refer to two different attributes of pain. The use of both pain and the loss of function in spinal conditions are better to use in combination, since many spinal conditions contain a combination of the two factors.

According to Feise and Menke (2001) using a 5-point scale for each item, the patient ranks his or her perceived ability to perform a specific task and/or the quantity of pain at the present time ("right now, at this very moment") by selecting one of the five response points that are anchored by polarized statements (0 = no pain or full ability to function; 4 = worst possible pain and/or unable to perform this function at all).

For scoring purposes, the 10 items of the FRI were totalled according to the responses given, divided by the total possible points available and then multiplied by 100 to produce a percentage value, as recommended by Feise and Menke (2001). The range of possible scores is zero percent (no disability) to 100 percent (severe disability). The higher the score, the higher the perceived pain and dysfunction (Feise & Menke, 2001).

3.3.3.2 Fear Avoidance

The following questionnaire was used to evaluate fear avoidance:

3.3.3.2.1 Fear Avoidance Beliefs Questionnaire (FABQ)

The FABQ is an instrument that contains 16 items and is divided into two subscales. The first is a 4-item subscale regarding physical activities and the fear avoidance beliefs towards them (FABQ/pa). The second is a 7-item subscale regarding work and related activities and the fear avoidance beliefs towards them (FABQ/w) (Swinkels-Meewisse *et al.*, 2003).

Items are scored on a 7-point Likert scale ranging from 0 (strongly disagree) to 6 (strongly agree). Total score for the FABQ/pa ranges from 0-24 and the total score for the FABQ/w subscale ranges from 0-42 (Swinkels-Meewisse *et al.*, 2003). The two subscales show sound internal consistency (Swinkels-Meewisse *et al.*, 2003).

3.3.3.3 Kinesiophobia

The Tampa scale for kinesiophobia (TSK) was used to measure fear of movement.

3.3.3.3.1 The Tampa Scale of Kinesiophobia

A fear of movement and activity has been suggested to be measurable by the Tampa Scale of Kinesiophobia (Kori *et al.*, 1990; Vlaeyen *et al.*, 1995). This instrument consists of a questionnaire that includes a 17-item set of questions and was developed as a means of identification of a fear of injury because of movement and/or activities (Swinkels-Meewisse *et al.*, 2003).

Items are scored on a 4-point Likert scale with scoring possibilities ranging from ‘strongly disagree’ (score = 1) to ‘strongly agree’ (score = 4) (Swinkels-Meewisse *et al.*, 2003). The scores of items 4, 8, 12 and 16 were reversed and then calculated.

3.3.3.4 Exercise Intensity

This study attempted to measure the intensity of the exercises as well as the exercise programmes.

3.3.3.4.1 The Borg Rate of Perceived Exertion (RPE) Scale

For the purpose of this study the Borg 6 to 20 rating of perceived exertion (RPE) scale was used in order to determine the intensity of different exercises in different programmes and to determine whether the intensity of the exercise was too easy or too difficult and whether the change from one programme to the next was sufficient.

To induce a training effect but not to influence exercise compliance in a harmful way or aggravating symptoms is a challenge of remedial exercise therapy that needs to be investigated (Dawes *et al.*, 2005). The monitoring of exercise intensity during exercise in healthy subjects has been measured effectively by the rate of perceived exertion (RPE) scale (Borg *et al.*, 1987). Clinical populations have also been monitored using this scale when exhibiting symptoms (Bateman *et al.*, 2001; Barker *et al.*, 2003).

Below is an example of the RPE scale used in the present study.

Table 3.1: Borg RPE Scale (Williams & Eston, 1996)

6 No exertion at all	14
7 Extremely light	15 Hard (Heavy)
8	16
9 Very light	17 Very hard
10	18
11 Light	19 Extremely hard
12	20 Maximal exertion
13 Somewhat hard	

An ability to sense effort has been reported to be well developed and in regular use in humans (Williams & Eston, 1996). Humans can sense when to stop or to continue during vigorous physical activity and can account overall feelings of exertion to particular sites, such as in the chest or arms and whether a sensation becomes maximal (Williams & Eston, 1996; Dawes *et al.*, 2005).

Humans can numerically scale various levels of exercise to which they are subjected to with some experience of physical activity (Williams & Eston, 1996).

As exercise intensity increases, there is a linear increase in the rate of perceived exertion in the 6 to 20 RPE scale, which is closely linked with physiological responses such as heart rate and oxygen use, which also increases linearly (Williams & Eston, 1996). Exertional symptoms such as breathlessness and muscle pain also increase accordingly (Borg *et al.*, 1985; Borg *et al.*, 1987).

As the subjective perception of the exercise changes, the RPE consists of numbers that are anchored to verbal responses that will change as the subject experience subjective changes (Williams & Eston, 1996). Subjects had to rate their own perception of a specific exercise with a number value on the scale for each exercise and this was then compared afterwards.

3.3.4 Physical Testing

The following tests were used to assess physical status:

3.3.4.1 Neurodynamic Testing

Popular accessory testing in the investigating of musculoskeletal injuries such as the straight leg raise test and the slump test have recently emerged and is used in the assessment of neural tissue mobility and sensitivity to mechanical stress (Herrington *et al.*, 2007). The categorizing of patients into groups with dissimilar prognosis and measured disease severity is the goal of diagnostic instruments in low back pain cases (Mens *et al.*, 2001). The value of both physical examinations and radiographic measurements is limited however (Mens *et al.*, 2001). A need thus exists for the use of simple tests with high validity, sensitivity and specificity (McCombe *et al.*, 1989).

3.3.4.1.1 Straight Leg Raise Test

Used as an aid in the diagnosis of low back pain conditions, the passive straight leg raise test is frequently used to assist clinicians (Jönsson & Strömqvist, 1995; Jönsson & Strömqvist, 1996). There is however, a lot of doubt in the best use of the test in terms of how it should be performed, the mechanism of its limitation and the clinical significance (Van den Hoogen *et al.*, 1996).

Pain during the passive straight leg raise test has been suggested to be because of the compression of the nerve root (O'Connell, 1943; Falconer *et al.*, 1948). This has been suggested to be caused by the sciatic nerve root being unable to move away from a disc protrusion, since it is fixed between the dura and the intervertebral foramen and thus the ensuing compression and induced traction-generated mechanism can cause pain (Inman & Saunders, 1942; Falconer *et al.*, 1948). The path of the nerve root movement has been reported as caudal but also as lateral towards the pedicle and so towards any posterolateral disc herniation (Rebain *et al.*, 2002).

The dura might be a contributor in the production of pain since it has been reported that the dura moves less than the intrathecal nerve root at the pedicle and thus experiences more strain (Rebain *et al.*, 2002).

It has been suggested that an effect on the outcome of the passive straight leg raise test can be influenced by a disc protrusion (Rebain *et al.*, 2002). Low back pain can result during a central prolapsed of the disc (Falconer *et al.*, 1948); both leg pain and back pain can result from a posterolateral protrusion (Rebain *et al.*, 2002) and leg pain alone can be produced by a lateral protrusion (Edgar & Park, 1974). It has also been reported that an improvement in the passive straight leg test result might not occur even if a decline in the size of the protrusion over time occurs (Thelander *et al.*, 1992).

Examination of the exit of the sciatic nerve from the pelvis during the straight leg raise test occurs only after 2.54-5.08 cm of leg raising and is evident after 20-30 degrees at the intervertebral foramen (Rebain *et al.*, 2002). The greatest amount of motion takes place at the L5-S2 level at 60-80 degrees of the passive straight leg raise test, but little movement occurs at L3 and higher (Inman & Saunders, 1942; Goddard & Reid, 1965). Movements of 4-5 mm at the S1 nerve root and 3 mm at the L5 nerve root has been reported (Inman & Saunders, 1942; Goddard & Reid, 1965). However, there is a decline of movement reported with age, probably due to adhesion from the sciatic nerve and the neighboring tissue (Goddard & Reid, 1965).

Damage to related ligamentous structures and collateral creation of an inflammatory focus over the dural cuff of the nerve have also been reported as possible pain producing mechanisms during the passive straight leg raise test (Inman & Saunders, 1942). Other factors could also include possible nerve root edema (Pennybacker, 1940; Holmes & Sworn, 1945; Falconer *et al.*, 1948); nerve root irritation (Goddard & Reid, 1965; Epstein *et al.*, 1972) and intervertebral foramen venous obstruction (Hoyland *et al.*, 1989; Kobayashi *et al.*, 1993).

The passive straight leg raise test has been reported to be a test for the assessment of neural tension and hamstring length (Loudon *et al.*, 1998). A defensive hamstring muscle reaction can lead to a restriction in the result of the passive straight leg raise test in order to protect the structure from possible damage (Goddard & Reid, 1965; Goeken & Hof, 1991; Ismaiel & Porter, 1992; Goeken & Hof, 1993; Hall *et al.*, 1995; Hall *et al.*, 1998).

A limited extensibility of the hamstring muscles in asymptomatic subjects and restricted extensibility produced by a defensive reaction to avoid nerve stretch is not able to be distinguishable by the passive straight leg raise test (Goeken & Hof, 1991; Goeken & Hof, 1993; Goeken & Hof, 1994). Hall *et al.* (1995) and Hall *et al.* (1998) supported these conclusions. They further reported that radiculopathy patients showed hamstring muscle response before reporting onset of pain. Hall *et al.* (1998) reported that such hamstring defense reaction in protecting inflamed nerve roots reflected a heightened mechanosensitivity of the nervous system. It is thus clear that the passive straight leg raise has to be interpreted with caution.

For the purpose of this study, the technique described by Loudon *et al.* (1998) will be used, in which the subject was placed supine on an examining table with the arms at the side. The subject's leg was gradually lifted into hip flexion while keeping the knee extended. Adding passive cervical flexion, dorisiflexion and plantar flexion may add tension to several nerve pathways by adding sensitization. This was added after the subject's leg reached maximum length. Reproduction of back or leg symptoms for tightness indicated a positive finding. Both legs were tested in this way. The same examiner performed the tests each time.

If the subject experienced leg symptoms when lifting the unaffected leg, it places tension on the nerve root on the unaffected side together with causing tension centrally along the midline of the cauda equina and to the nerve roots on the opposite leg (McGill, 2002). Simultaneous cervical flexion can also sometimes produce pain. An organic sign of disc lesion is when pain is reproduced on the symptomatic side, which may be a more central lesion (McGill, 2002). Neural tension can be indicated when pain is produced along specific pathways (Loudon *et al.*, 1998).

Figure 3.1 : The Straight Leg Raise Test

A protractor goniometer was used to measure the total amount of hip flexion after the subject's leg reached maximum height (Borms & Van Roy, 1996).

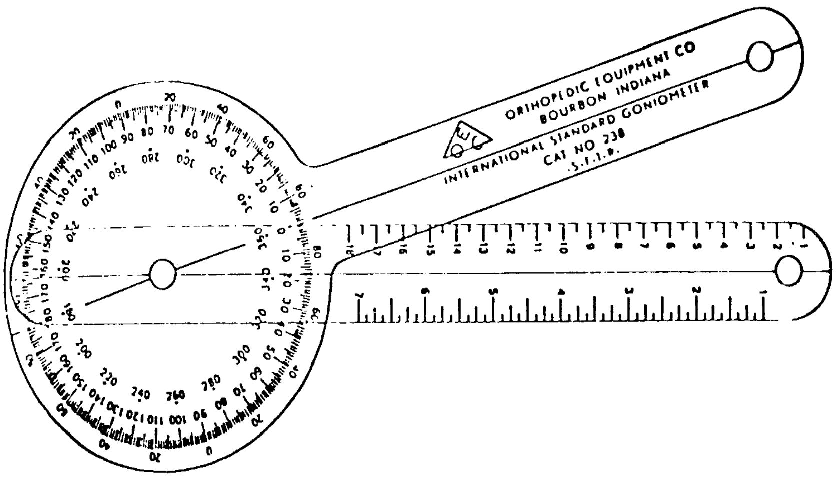


Figure 3.2: The International Standard Protractor Goniometer

The angle between two bony landmarks is measured by the goniometer, and the angle is recorded when the maximum height is reached. A pelvic tilt occurs with a consequent reduction of the lumbar lordosis during straight leg raise testing (Borms & Van Roy, 1996). Because of this, the straight leg was raised to its maximum level of perceived comfort. When the subject experienced discomfort, either pain or stiffness in the leg or back, the amplitude measurement was recorded along with reproduction of symptoms. The landmarks used for this test were the tip of the greater trochanter and the lateral femoral epicondyle, according to the recommendations of Borms & Van Roy (1996).

However, it has to be noted that, as reported by Herrington *et al.* (2007), even asymptomatic subjects tend to have positive neurogenic response to structural differential of the straight leg raise test and the slump test. The finding of positive structural differentiation does not necessarily imply the presence of neural pathology.

Neural pathology is thus not necessarily indicated by the finding of positive structural differentiation. To be regarded as being positive test result of an underlying pathology, the test outcome has to be greater than for asymmetric subjects found by studies such as those conducted by Herrington *et al.* (2007). It also shows a great difference in symmetry between limbs (Herrington *et al.*, 2007). This consideration has to be taken into account to avoid possible false-positive results and this is also why other tests have been considered in the present study.

3.3.4.1.2 The Slump Test

Neural tension is very often measured by the Slump Test (Loudon *et al.*, 1998). Tensing of the sciatic nerve and irritation of the lumbar nerve roots is the goal of this specific test (McGill, 2002).

During this test, the subject is seated on an examination table and is put through a series of motions, stopping if any symptoms occur or if any resistance to motion is occurred. The subject started by placing their hands behind the back, rounding the shoulders and flexing the neck, after which the examiner used one hand to passively extend one of the subject's legs (Loudon *et al.*, 1998). The sciatic nerve is not the cause of pain if pain levels were not increased during the flexion of the neck (McGill, 2002).

The test is performed by first dorsiflexing the foot, and early resistance or a reproduction of back and/or leg symptoms indicate a positive finding. When lifting the head causes a release of pressure, it confirms the existence of neural tension. The test was performed on both sides (Loudon *et al.*, 1998). The same examiner performed the test on all occasions.

Figure 3.3 : The Slump Test

3.3.4.2 Muscle Endurance Testing

Biering-Sorensen (1984) suggested that those who are at greater risk for future back problems show a noticeable decrease in torso muscle endurance. McGill (2002) however, suggested that a better identification of those who have suffered from low back problems in the past can be found in the balance of endurance among the flexor, extensor and lateral musculature of the torso. Because all these muscle groups are involved in spine stability during practically any task, the endurance of all three muscle groups should be measured.

Simple tests that isolate these muscle groups should be used, and therefore the following tests have been selected because they all have a high reliability coefficient and are relatively easy to perform (McGill *et al.*, 1999):

3.3.4.2.1 The Sorenson Back Extension Test (The Ito Test Version)

The extensor muscle group of the trunk is measured very effectively by this test, especially the paraspinal muscles are very successfully measured, which includes the multifidus muscle (Ng *et al.*, 1997; Arokoski *et al.*, 1999) as well as the hip extensor muscle group (Demoulin *et al.*, 2004).

In those with chronic low back pain, it has been found that these subjects have a significantly decreased position holding time for this test (Hansen, 1964; Biering-Sorensen, 1984; Salminen *et al.*, 1992; Hultman *et al.*, 1993; Jorgensen, 1997; Simmonds *et al.*, 1998; Latimer *et al.*, 1999; Novy *et al.*, 1999;). Thus, a decline in isometric endurance of the trunk extensor muscles has been argued to be associated with chronic low back pain and its effects (Demoulin *et al.*, 2004).

Greater levels of severity among those with chronic low back pain have been suggested to be associated with poorer test performance during extensor endurance tests (Mannion & Dolan, 1994; Lindstrom *et al.*, 1995; Jorgensen, 1997). This makes the Sorensen test very applicable to use with subjects with chronic low back pain.

McGill (2002:226) reported that: "…*the back extensors are tested in the 'Biering-Sorensen position' with the upper body cantilevered out over the end of a test bench and with the pelvis, knees and hips secured. The upper limbs are held across the chest with the hands resting on the opposite shoulders. Failure occurs when the upper body drops from the horizontal position."*

The test is stopped after four minutes in those subjects who experience no issues with the test (Demoulin *et al.*, 2004). Biering-Sorensen (1984) reported that during a one year period, a position-holding time of less than three minutes in males can prompt low back pain, whereas a holding time of more than 3.3 minutes reports a low percentage of low back pain during a one-year period. A risk of low back pain with a holding time of less than 58 seconds has been predicted to increase the risk three-fold (Luoto *et al.*, 1995). In healthy subjects, the mean extensor endurance times for mixed gender groups range from 77.76 – 129 seconds (Mannion & Dolan, 1994; Luoto *et al.*, 1995; Moreland *et al.*, 1997; Simmonds *et al.*, 1998).

Healthy women on average typically have a tendency to produce longer extension endurance times than healthy men, with women averaging 142 – 220.4 seconds while men scores an average of 84 – 195 seconds (Mannion & Dolan, 1994; Mannion *et al.*, 1997; Kankaanpää *et al.*, 1998).

Mixed gender groups with low back pain scores a mean endurance time between 39.55 – 54.5 seconds, while men with low back pain scores 80 - 194 seconds and women score 146 – 227 seconds (Moffroid *et al.*, 1994; Simmonds *et al.*,1998; Moreau *et al.*, 2001). For low back pain cases in men and women, the Sorensen test has been shown to have prognostic worth (Adams *et al.*, 1999; Sjollie & Ljunggren, 2001).

Figure 3.4: The Sorensen Back Extension Test

For the purpose of this study, the test was modified according to Ito *et al.* (1996) with two differences being the subject's feet being held down and the other that instead of hanging over the edge of a table, the subjects were placed in a prone position on an exercise mat on the floor. Arms were placed alongside the body and the feet were held in place. Because arm position influences the location of the centre of gravity, the modification made with the arms will affect the mass moment of the upper body and therefore influence the test performance (Mayer *et al.*, 1999).

Upon starting, the subjects would lift their upper bodies from the ground until their chests were slightly off the floor while flexing the neck as much as possible without creating discomfort in the neck. This in turn increased the activity level of the erector spinae muscles (Ito *et al.*, 1996). The position was then held for as long as comfortably possible. Subjects were allowed to stop when experiencing discomfort, either in the form of pain or muscle fatigue.

Figure 3.5 : The Ito Test

Some subject experience increased levels of difficulty with this test, no matter how much contraction takes place (Moreau *et al.*, 2001). Biering-Sorensen (1984) reported that 24% of their sample could not complete the test due to back pain followed by pain in the legs or abdomen. Latikka *et al.* (1995) reported a 50% failure rate because of back pain or fatigue. Other side-effects that have been recognized with the test include cramps of the calves, neck pain, discomfort in the head, abdominal pain and breathlessness (Latikka *et al.*, 1995; Moreland *et al.*, 1997).

The time the position was held, was measured with a stopwatch. The reason for stopping was also noted. Test results of subjects who stopped for pain reasons might not have been an accurate reflexion of muscle performance (Biering-Sorensen, 1984; Mannion & Dolan, 1994; Latikka *et al.*, 1995; Moreland *et al.*, 1997; Latimer *et al.*, 1999). It is thus very important to note the reason for stopping and to be able to compare from pre-test to post-test.

It has been suggested that the Ito test might result in less spinal loading than the Sorensen test, which was why it was selected in the present study (Demoulin *et al.*, 2004). The input of the hip extensor muscles has been suggested to be smaller because the lower body is not fixed into position with straps (Plamondon *et al.*, 2002).

Lasting pain and adverse effects with the Sorensen test have seldom been reported, and is thus a relatively safe submaximal test and can be used safely and successfully (Simmonds *et al.*, 1998). This is because the extensor muscles of the low back contract well below the threshold of the maximal voluntary contraction (MVC) (Moffroid *et al.*, 1993; Mayer *et al.*, 1995).

Subjects with no low back pain sustained the endurance contraction at the following levels:

- Slim, strong subjects: 20-25% of MVC (Jorgensen & Nicolaisen, 1986)
- Subjects with no low back pain or low back pain that does not prevent work: approximately 60% of MVC (Hultman *et al.*, 1993)
- Untrained and overweight subjects: approximately 70-75% of MVC
- Subjects with chronic low back pain: approximately 85% of MVC (Jorgensen & Nicolaisen, 1986)

Even though the Ito test is a good variant, the Sorensen test is more recommended than the Ito test (Demoulin *et al.*, 2004). This is because the Ito test version still requires more validation before it can be considered a valid instrument (Ito *et al.,* 1996). The test is agreed upon to be very cost effective and easy to perform, can be done in a short time and does not necessitate any special equipment, either in its original form or some sensible variation of the test (Moreau *et al.*, 2001). Subject motivation unfortunately plays a big role in the performance of the test, and low levels of motivation due to factors such as fear avoidance behaviour can influence the outcome of the test (Kankaanpää *et al.*, 1998).

3.3.4.2.2 Side Bridging Endurance Test

This test measures the lateral muscle group. The test is described in McGill (2002: 225): "*The lateral musculature is tested with the person lying in the full side-bride position. Legs are extended, and the top foot is placed in front of the lower foot for support. Subjects support themselves on one elbow and on their feet while lifting their hips off the floor to create a straight line over their body length. The uninvolved arm is held across the chest with the hand placed on the opposite shoulder. Failure occurs when the person loses the straight-back posture and the hip returns to the ground.*" The only change made to the test used in the present study was that the subjects were required to place the uninvolved hand on the hip, as shown in fig. 3.6.

Figure 3.6 : The Side Bridging Endurance Test

3.3.4.2.3 Flexor Endurance Test

This test measures the flexor muscle group. The test was performed with the subject in a sit-up posture with the back forming a 60° angle with regard to the legs. This angle was achieved with the subject placing the hands on the knees for support and leaning back until the desired angle was achieved. The test was started when the subject let go of the knees and placed them on the shoulders. Both knees were flexed 90°, the arms folded across the chest with the hands placed on the opposite shoulder. The feet were kept in place by another person holding them down. To begin, the subject held the isometric posture as long as possible. Time was measured using a stopwatch. Failure was determined to occur when the subject could no longer continue. Subjects were also allowed to stop if they felt pain or muscular fatigue in their low back (McGill, 2002).

Figure 3.7: The Flexor Endurance Test

3.3.5 The Exercise Programmes

The intervention consisted of two separate programmes. The first programme was for the control group. This group received an exercise programme that was considered to be conservative in nature. They completed the programme twice per week with a session lasting for approximately 35-40 minutes. This programme remained unchanged throughout the 12-week intervention timeframe.

The second programme was considered more aggressive in terms of the exercises performed as well as the intensity of the programmes. The subjects completed the programme for four weeks after which it was progressed to a more difficult level. After another four weeks (eight weeks in total) the programme was progressed again to a more difficult level and was again completed for four weeks (12 weeks in total). This group was the experimental group. The programme was also completed twice per week with a session lasting for approximately 60 minutes, along with the back school session.

All of the exercises in the experimental group were performed with stabilisation (abdominal bracing). All of the exercise sessions were supervised by the principle researcher who is a qualified rehabilitation specialist. Below follows the complete descriptions of the exercise programmes.

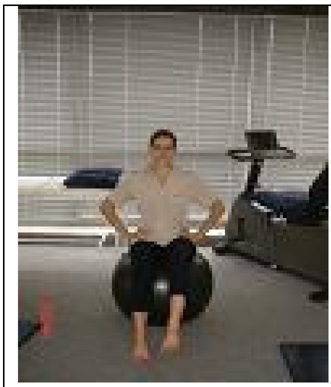
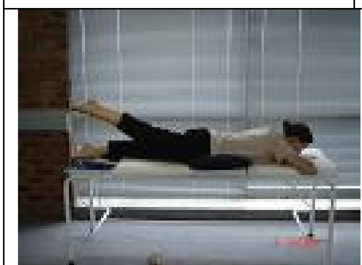
3.3.5.1 Control Group (Conservative Exercise Programme)

Resting time between sets was 20 seconds.

Illustration	Exercise	Sets	Reps
	**Cycling**: This was performed on a recumbent cycle, model Vision Fitness R2150. Subjects cycled for five minutes at Level 2 (43-55 watt) at an RPM (revolutions per minute) of 60-70.	5 min.	

	**Both Knees to Chest Stretch:** Performed with the subject in supine position. Subject started by pulling up both knees towards the chest, lifted to the position of mild discomfort, held for 12 seconds (Prentice, 2004).	2	12 sec.

	**Hamstring Stretch:** Performed with subject in supine position. The subject lifted up one leg, placed hands at the back of the knee, pulling the leg up with knee slightly bent, stretching the hamstring. The leg was lifted to a position of mild discomfort. The opposite leg was placed flat on the ground. The position was held for 12 seconds.	2 sets each leg	12 sec.
	**Periformis Stretch:** Performed with subject in supine position. Ankle of leg was placed on knee of opposite leg, hands behind the knee. The knee was pulled towards the chest (Prentice, 2004). Held position for 12 seconds.	2 sets each leg	12 sec.
	**Roll Both Knees to Side:** Performed with subject in supine position. Arms were placed outstretched to assist with stability. Knees were bent and placed together. Both feet were lifted off the ground about 10 cm. Knees were then kept together and rolled from side to side, slowly and with control, only up to the point of comfort (Prentice, 2004).	2	10 to each side

	**Sit on Stability Ball**: Performed with subject sitting on a 75 cm stability ball. Hands were placed on hips. Subjects were then asked to lift one leg at a time about 5 cm off the ground, balance in the position for a couple of seconds and repeat with the other leg. Subject had to keep upright without counterbalancing due to altered stability position.	3	30 sec.
	**Alt Superman on All-fours:** Subject started in the all-fours position with the hands under the shoulders and the knees under the hips. The opposite arm and leg were raised simultaneously and only up to horizontal level. The position was then held for 5 seconds. Arm and leg then returned to starting position and the other opposites were raised and held. Subject maintained neutral spine (McGill, 2002).	2	4 each side
	**Hip Lifts (Feet Flat on Floor):** Subject started in the supine position with knees bent and feet flat on the floor. The arms were kept next to the sides. The hips were then lifted until they were fully extended. The position was held for 5 seconds. The hips were lowered and the exercise repeated (Prentice, 2004).	2	10
	**Prone Alt Leg Lifts:** Subject started in the prone position with a pillow under the abdomen to help maintain neutral spine. One leg was lifted until the foot was about 10 cm off the ground with the	2	6 each leg

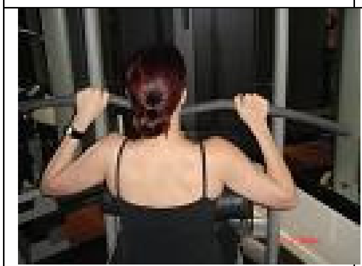
	leg kept straight. The position was held for 5 seconds. The leg was lowered and exercise repeated with the other leg (Prentice, 2004).		
	**Prone Alt Arm and Leg Lifts:** Subject started in the prone position with a pillow under the abdomen to help maintain neutral spine. The opposite arm and leg were lifted simultaneously about 10 cm off the ground. Both the arm and the leg had to be kept straight. The position was held for 5 seconds. The arm and the leg were lowered and repeated on the other side (Prentice, 2004).	2	6 each side

3.3.5.2 Experimental Group (Progressive-Aggressive Programme)

This programme was divided into three progressive exercise programmes. Selected exercises were made to be more difficult from one programme to the next. This was done to increase the intensity of each programme. The exercises were also more aggressive and thus harder to perform than the control group exercises. Each programme was performed for four weeks (eight sessions) before it was progressed to the next programme. Resting time between sets was 30 seconds.

3.3.5.2.1 Programme 1

This programme was performed from the start of the programme to the end of Week 4.

Illustration	Exercise	Sets	Reps
	**Cycling**: This was performed on a recumbent cycle, model Vision Fitness R2150. Subjects cycled for 5 minutes at Level 2 (43-55 watt) at a RPM (revolutions per minute) of 60-70.	5min	
	**Hamstring Stretch with Foot Flexion:** Performed with subject in supine position. Lifted up one leg, placed hands at the back of the knee, pulled leg up with knee slightly bent until the hamstring was stretched. Subject then performed 20 plantar/ dorsiflexion step-off movements with the foot. Opposite leg was placed flat on the floor.	3 each leg	20
	**Side Lying Quadricep Stretch:** Subject lay on her side. The top leg was bent and the foot grasped with the hand. The heel of the foot was pulled towards the buttocks to stretch the quadricep muscle. Position was held for 12 seconds.	3 each leg	12 sec.
	**Lat Pulldown to the Front:** Subject was seated in a standard lat pulldown machine. The bar was grasped with both hands slightly wider than shoulder width. The bar was pulled down towards the chest and in front of the face. This enhanced the role of several spinal extensors, particularly the latissimus dorsi (McGill, 2002). Weight selection: men = 3 plates (12 kg); women = 2	3	15

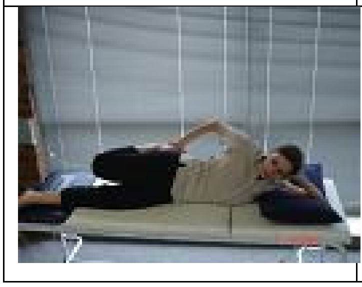
	plates (7 kg).		
	**Side Bridging (on Knees):** Subject lay on her side with the knees bent 90°, supported on the elbow and hip. The free hand was placed on the hip. The torso was then straightened until the body was supported on the elbow and the knee. Held position for 15 seconds (McGill, 2002).	3 each side	15 sec.
	**High Cable Horizontal Adduction (Downwards)**: Subject stood in a cable pulley machine and gripped the handle with one hand in an extended abducted position. The arm was kept straight throughout the movement. The arm was then adducted towards the midline of the body and in line with the navel, and then slowly released back to the starting position. Torsion forces had to be resisted by keeping the body straight.	3 each arm	15
	**Hip Lifts with Feet on Bench:** Subject started in the supine position with the feet on a 46 cm bench in a 90° angle with the arms next to the sides. The hips were raised off the floor until the hips were in full extension. The hips were then slowly lowered and the exercise was repeated.	3	15
	**Alt Superman on Stability Ball:** Subject started in a prone position with a 75 cm stability ball under the abdomen, with hands and feet placed on the ground. The alternative arm and	3	6 each side (12 total)

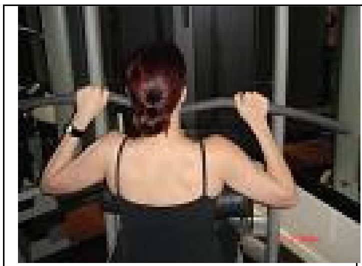
	leg were raised until horizontal. The position was held for 5 seconds. Both limbs were slowly lowered until on the ground again. The other pair of opposites was then raised. This had to be done while maintaining balance on the ball.		
	**Abdominal Crunches (Feet on Bench):** Subject started in the supine position with the feet on a 46 cm bench at a 90° angle with the hands behind the head. Eyes had to be kept on the ceiling throughout the entire exercise. The shoulder blades were then raised off the floor, with hands supporting the head and neck. The body was then lowered and the movement repeated.	3	20

3.3.5.2.2 Programme 2

Exercises from the first programme are now progressed to increase their difficulty level. It was performed from Week 4 to Week 8. Exercises as well as progression techniques will be discussed.

Illustration	Exercise	Sets	Reps
	**Cycling:** Intensity was increased as follows: Level was increased to 3 (65-75 watt) and the RPM was increased to 65-75.	5 min.	

	**Hamstring Stretch with Step-off:** Subject started in the supine position.Leg was held up with rope or towel, stretched for 12 seconds. The subject performed 12 plantar/dorsiflexion step-offs with leg in extended position. After the 12 step-offs the leg was pulled slightly further back and held for another 12 seconds. The non-involved leg lay flat on the ground.	3 each leg	12;12; 12
	**Side Lying Quadriceps Stretch:** Stayed the same as in the first programme.	3 each leg	12 sec.

	**Lat Pulldown to Front:** Subject was seated in a standard lat pulldown machine. The bar was grasped with both hands slightly wider than shoulder width. The bar was then pulled down towards the chest and in front of the face. This enhanced the role of several spinal extensors, particularly the latissimus dorsi (McGill, 2002). The intensity of this version of the exercise was increased by adding more repetitions. Subjects now performed 25 repetitions. The weight stayed the same.	3	25

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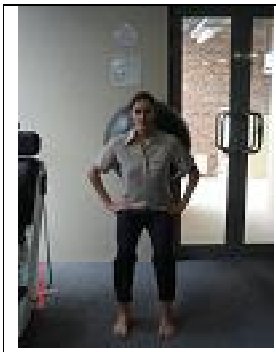
	**One arm DB Row:** Subject stood with the same arm and same leg placed on a 46 cm bench. The other leg was placed on the floor to give a wide balance position. The other arm held a hand-weight. The weight was raised to the iliac crest with the elbow raised towards the ceiling. Torsion was resisted by bracing the abdominal muscles. The weight was then lowered and the movement repeated. The upper back had to be kept straight and parallel to the floor (Delavier, 2001). The following weight selection was used: men → 5 kg, women → 2 kg.	3 each side	15

	**Side Bridging (on Feet):** Progression of this exercise entailed balancing on the feet and the elbow instead of the knees. The position was still held for 15 seconds.	3 each side	15 sec.
	**Low Cable Shoulder Flexion (Straight Arm):** The subject faced away from a cable pulley machine and gripped a handle in one hand. The shoulder was then flexed to 45° in the sagital plane. The arm was then returned to the starting position and the movement was repeated.	3 each arm	15

	**Ball Squat Against Wall:** Subject leaned against a wall with a 75 cm stability ball placed in the lower back. Feet were placed forward from the vertical position of the hips, slightly apart. Hands were placed on the hips. The knees were bent to simulate a squat movement. Subject squatted no lower than 45° of knee flexion. Subject then rose back up to the starting position and the movement was repeated.	3	15
	**Hip Lifts (Feet on Ball):** This exercise was performed exactly as in the first programme, except that the feet were placed on a 75 cm stability ball and not on a bench. The subject performed 15 repetitions.	3	15

	**Alt Superman (Sweeping Hand on Floor Upon Return and Up Again):** This exercise was performed exactly as in the first programme, except that instead of alternating the arm and leg combination, the arm and leg just swept the ground upon return and were extended again. No weight was placed back onto that side. One arm and leg combination first finished its repetitions; then the other side was used (McGill, 2002).	3	6 each side (12 in total)

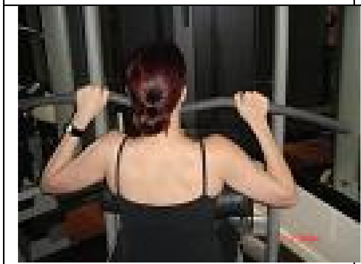
	**Abdominal Crunches (Feet on Stability Ball):** Exactly as in the first programme, except that the feet were placed on a 75 cm stability ball. The repetitions were also increased to 25 per set.	3	25

3.3.5.2.3 Programme 3

This programme was designed to be the most difficult after progression from the previous two. It was performed from Week 8 to the end of the programme at Week 12. Progression and techniques are discussed below.

Illustration	Exercise	Sets	Reps
	**Cycling:** This exercise was progressed by increasing the level to Level 4 (75-94 watt) and the RPM to 70-80.	5 min.	

	**Periformis Stretch:** Performed with subject in supine position. Ankle of leg was placed on knee of opposite leg, hands placed behind knee. The knee was pulled towards the chest (Prentice, 2004). The exercise was held for 30 seconds.	2	30 sec.
	**Rotation Stretch:** Subject started in the supine position. One leg was bent and placed over the knee of the other leg. The opposite hand in relation to the bent leg was placed on the knee. The bent leg was pulled over to the side to stretch the buttocks. Shoulders had to	2	30 sec.

	be kept down on the ground. Position was held for 30 seconds.		
	**Side Lying Quadriceps Stretch:** This exercise was performed exactly as in the previous programmes; only it was now held for 30 seconds and not 12 seconds.	2	30 sec.
	**Lat Pulldown to Front:** This exercise was performed exactly as in the previous programmes. Intensity was increased by means of adding more weight. One plate was added. Men now exercised with 4 plates (15 kg) and women with 3 plates (12 kg). Repetitions were again15.	3	15

	**High Cable Pulldown to Opposite Hip with Both Arms:** The subject stood in cable pulley machine and gripped the handle with both hands. The hands were then pulled across the body towards the opposite hip. Controlled torsion forces were encouraged to teach the subject control in the torsional plane.	3 each side	15
	**Seated Cable Row:** Subject was seated in a standard cable row pulley machine. A V-handle was used. Subject sat upright with feet on the support plates and slightly bent at the knees. The back had to be kept upright during the movement, no flexion or extension was allowed at the hips. The handle	3	15

	was then pulled towards the navel while keeping upright. It was then slowly lowered and the movement was repeated. Men used 2 plates (10 kg) and women used 1 plate (5 kg).		
	**Ball Squat Against Wall (With Weight):** This exercise was performed exactly as in the previous programme, except that the subject held onto a set of hand-weights. Men used 3 kg dumb bells and women used 1.5 kg dumb bells.	3	15

	**Side Bridging (on Feet, Lifted Side):** The starting position was exactly the same as for the previous version of this exercise but was no longer a holding exercise. Instead, the hips were raised in an up and down motion. The subject was instructed to raise the hips towards the ceiling, while keeping the hips extended.	3 each side	12
	**Hip Lifts With One Leg at a Time (Feet on Bench):** The starting position for this exercise is the same as in the previous versions. Intensity is increased by performing the exercise in the same way as previously, but only with one leg at a time. This also increased the volume of the exercise by ensuring that double the amount of sets were done.	3 each leg	10

	**Alt Superman:** The starting position for this exercise was exactly the same as for the other versions. Intensity was increased in the following manner:The arm and leg were held at end range of motion. The subject performed 5 flexion/extension movements with the hand and foot, while the arm and leg were held at the end range of motion.	3	6 each side (12 in total)

	**Abdominal Crunches (Lying on Ball):** This exercise was performed with the same technique as for the other versions in that the hands supported the head and the eyes looked up at the ceiling. Intensity was increased by having the subject lie on a 75 cm stability ball that required more effort to maintain balance. More repetitions were performed. Subjects performed 30 repetitions instead of 25.	3	30

3.3.6 The Back School

The back school formed the educational part of the rehabilitation programme. An educational document called *The Only Information You will Ever Need to Treat Your Back Pain*was composed from scientific literature and provided information on the following topics:

- **Discussion of correct and proper anatomy**
  These discussions focused on the involved anatomical structures of the lower back and their possible influence in the cause of problems.
- **Discussion of proper ergonomics**

Certain tasks and movements in everyday life may worsen lower back problems. The discussions focused on proper lifting and application techniques.

- **Avoiding bed rest and remaining active with normal activities that were avoided because of back pain**

  Bed rest is detrimental to lower back problems. These discussions focused on the importance of avoiding bed rest.
- **Discussion of LBP history**

  Previous low back pain injury is a major causal factor for future events. The importance of avoiding risk factors for this reason was discussed.
- **Discussion of risk factor prevention**

  Risk factor prevention will drastically decrease the chances of suffering from a future back pain event. Different prevention factors were discussed here.
- **Importance and benefits of exercise**

  Exercise therapy is regarded as one of the mainstay treatments for chronic low back pain. These discussions highlighted the importance and benefits of exercise therapy as well as the safety of different exercises.
- **Work to achieve an internal locus of control**

  Internal locus of control correlates with a quicker and more complete recovery. These discussions were used to try and facilitate this change of perception in the subjects.

Both groups received an exact same copy of the document to read on their own before the start of the programme. The conservative exercise group only received the document to read. This is referred to as *low-intensity back school*. The experimental exercise group also had to read the document. In addition, they received one-on-one educational sessions discussing all of the topics in the document. This is referred to as *high-intensity back school*.

The educational sessions took place after the training sessions. The educational sessions took between 5-10 minutes each. The topics contained in the back school document were discussed more in-depth with the subjects on an individual basis. This served to provide education and understanding of living with chronic low back pain and thus provided a large part of the biopsychosocial approach which focuses on education.

CHAPTER 4
RESULTS AND DISCUSSION

4.1. Background and Objectives

The objective of the study was to determine the effect of exercise therapy on lower back pain.

4.2. Research Design

A [research] design is used to structure the research, to show how all of the major parts of the research project – the samples or groups, measures, treatments or programmes and methods of assignment – work together to try to address the central research questions.(Research methods, knowledge base; http://www.socialresearchmethods.net/kb/design.php).

An experimental design was used in this study. When making use of an experimental design, the researcher aims at creating two groups of respondents or research participants who are similar to each other. One group is then exposed to a programme, intervention or treatment and the comparison or control group not. In all other aspects, apart from the intervention, the two groups are treated equally.

If the two groups were the same before intervention, then differences in measurements after exposure are more likely to be due to the treatment. For this design to be successful it is very important that participants be randomly assigned to the two groups.

4.3 Methodology

Participants were randomly assigned to two groups: an experimental and a control group. The control group was given a conservative training programme that needed to be followed twice a week over a period of 12 weeks. The experimental group had to follow a more progressive and aggressive training programme. They followed three different training programmes (each with a 4-week duration) that progressively became more aggressive. The experimental group also completed the three different training programmes over a period of 12 weeks.

Pre-test and post-test measures were taken of each group and the experimental group had to complete questionnaires as well. To determine if the two groups were the same prior to intervention and if the interventions had the desired effect, the relevant test and control groups were compared in the following ways:

- The **Mann-Whitney** test was used to compare the experimental and control groups on all pre-test measurements in order to determine whether the two groups were similar before intervention.
- After intervention, the measurements were repeated (post-test). The two groups were once again compared by means of the **Mann-Whitney** test.
- To determine whether changes had taken place from the pre-test measurements to the post-test measurements within the groups, the scores within each group (the experimental group and the control group) were compared by means of the **Wilcoxon signed-rank test.**

4.4. Statistical Analysis

The collected measurements were captured on a computer and analysed by means of the Statistical Package for the Social Sciences (SPSS).

4.4.1 Descriptive Statistics

Descriptive statistics has been reported as a method for describing data in manageable and understandable forms(Babbie, 1992). Descriptive statistics presented within this study included the number of participants, minimum and maximum scores, mean scores and standard deviations. These descriptive statistics gives the reader an indication of the nature of the data on all variables measured for reference purposes.

- **Mean score**: The mean score is used to describe central tendency. The mean score is computed by adding up all the applicable values and dividing them by the number of cases. (Research methods, knowledge base; http://www.socialresearchmethods.net/kb/ statdesc.php).
- **Standard deviation**: The Standard Deviation shows the relation that a set of scores has to the mean of the sample. (Research methods, knowledge base;

http://www.socialresearchmethods.net/kb/statdesc.php). It gives an indication of the distribution of data around the mean on all variables measured. The higher the standard deviation, the more the data is dispersed.

4.4.2 Inferential Statistics

Test hypotheses about differences in populations on the basis of measurements were made on samples of patients(Tabachnick & Fidell, 1996).

4.4.2.1 Mann-Whitney Test

The Mann-Whitney test is a non-parametric test that is used to determine whether two samples are equivalent and drawn from the same single population. (Wikipedia, http://en.wikipedia.org/wiki/Mann-Whitney_U).

In our case the active and placebo groups were compared during the pre-test and again during the post-test. Ideally the two groups should be the same during the pre-test and differ in favour of the active group during the post-test.

4.4.2.2 Wilcoxon Signed-rank Test

The Wilcoxon signed-rank test is a non-parametric test that can be used to test two related samples or repeated measurements on a single sample. The Wilcoxon test involves comparisons of differences between measurements. It is often used to test the difference between scores of data collected before and after an experimental manipulation. (Wikipedia, http://en.wikipedia.org/wiki/Wilcoxon_signed-rank_test).

4.5. Results

Results of the analysis will be presented in the following order:

- Descriptive statistics for the experimental and control groups for pre-test and post-test data on all measurements
- Difference between the experimental and control groups on pre-test measurements
- Difference between the experimental and control groups on post-test measurements

- Difference between the pre-test and post-test measurements within the experimental group
- Difference between the pre-test and post-test measurements within the control group.

4.5.1. Descriptive Statistics for the Two Groups on all Measurements

These results are included simply as frame of reference for the reader to see how the two groups performed on all the measurements. The results are presented in tables 4.1 to 4.9.

Table 4.1: Descriptive Statistics per Group on Pre-test Measurements

Group		N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Age	18	18	57	33.00	10.347
	Weight (kg)	18	50	131	85.56	26.988
	Height (cm)	18	155	195	175.17	12.894
	BMI (kg/m^2)	18	19	36	27.17	5.973
	Hrs worked / day	18	5	15	10.19	2.573
	Time spent driving (minute)	18	.4	1800.0	169.189	494.9721
	Valid N (listwise)	18				
Control	Age	14	22	56	37.43	11.015
	Weight (kg)	14	59	106	79.11	14.369
	Height (cm)	14	152	190	170.57	10.761
	BMI (kg/m^2)	14	20	36	27.14	3.939
	Hrs worked / d ay	14	3	16	9.07	2.786
	Time spent driving (minute)	14	.0	1800.0	129.764	480.7294
	Valid N (listwise)	14				

A statistically significant difference was found at the 5% level of significance between the experimental and control groups for pre-test transport/driving time.

The transport/driving time for the experimental group was significantly higher than that of the control group. No statistically significant differences were found between the pre-test of the experimental and control groups for any of the other measurements.

It can thus be concluded that, as far as the rest of the pre-test measurements are concerned, the two groups were very similar. The process of randomisation has thus ensured that the groups were as homogenous as possible at pre-test, ensuring an even spread of respondents across both groups. However, the difference in driving time could be explained by the fact that one respondent in the experimental group worked very far from home, while some of the respondents in the control group worked from home; thus increasing the difference between the two groups.

Time spent driving and the amount of hours worked per day were also recorded. This was done because it is believed that increased time spent sitting might contribute to chronic low back pain (McGill, 2002). When commuting to work, travel time becomes a factor, especially when travel time becomes prolonged, involving sitting for extended periods of time. Vibration also plays a role, especially when driving in a car and the whole body is exposed to vibration. This might also contribute to chronic low back pain.

These two factors have been identified as causative factors (Andersson, 1997; Jansen *et al.,* 2002; Laursen & Scibye, 2002; Leboeuf-Yde, 2004). When combined, they may theoretically cause more problems than when a patient is exposed to only one of these. However, the results from the study are not indicative in this regard because some respondents travel long distances to work while others work from home. Future research is required to provide answers on this topic.

Time spent working may also be regarded as a causative factor, especially when static postures are maintained for long periods of time as is the case with office workers and computer personnel. The mean score for the amount of hours worked in the experimental group was 10.19 hours per week and 9.07 hours per week for the control group. This is more than the average work day of 8 hours per day. However, the high level of importance placed on work and returning to work in cases of low back pain have been discussed in detail in chapter 2.

Keeping patients away from work is not a sensible option. Work station modification and patient education have to play an important role in minimising strain placed on the patients with chronic low back pain to prevent absenteeism due to chronic low back pain.

Table 4.2: DescriptiveStatistics per Group on Pre-test and Post-test Measurements

Group		N	Minimum	Maximum	Mean	Std. Deviation
Experimental	VAS Pain Score Pre-test	18	12	86	54.44	18.231
	VAS Pain Score week 4	12	5	72	33.92	23.899
	VAS Pain Score week 8	11	5	43	19.27	11.585
	VAS Pain Score week 12	11	1	63	17.00	18.746
	Tampa Scale Pre-test	18	5	15	8.28	2.296
	Tampa Scale week 4	12	4	12	8.25	2.006
	Tampa Scale week 8	11	4	10	7.27	1.849
	Tampa Scale week 12	11	4	10	6.82	1.940
	Valid N (listwise)	11				
Control	VAS Pain Score Pre-test	14	25	84	52.57	19.358
	VAS Pain Score week 4	13	10	64	30.77	14.313
	VAS Pain Score week 8	10	5	63	28.80	21.364
	VAS Pain Score week 12	10	2	35	13.40	11.462
	Tampa Scale Pre-test	14	6	11	8.36	1.151
	Tampa Scale week 4	13	4	12	8.08	2.019
	Tampa Scale week 8	10	5	12	8.40	2.119
	Tampa Scale week 12	10	4	14	7.30	2.830
	Valid N (listwise)	10				

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group.

- VAS pain score: The pre-test measurement was significantly higher than the post-test measurement.

This shows a favourable result for the present study, as a lower score shows an improvement in pain levels. It has been shown that pain elimination is not a primary goal in the treatment of chronic low back pain (Staal *et al.,* 2003; Staal *et al.,* 2005). But the fact that the VAS pain score in the present study has decreased significantly within the experimental group demonstrates that an aggressive-progressive exercise programme is effective in treating pain associated with chronic low back pain, especially since the VAS score is below 30.

Pain was not completely eliminated in the experimental group (VAS pain score = 17.00) but this coincides with other studies that report that pain elimination might not be realistic in chronic low back pain due to the recurrence rate of low back pain (Shirado *et al.,* 2005; Staal *et al.,* 2005).

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the control group.

- VAS pain score: The pre-test measurement was significantly higher than the post-test measurement.

The control group also showed good improvement in their pain score. It has been proven that conservative exercise programmes are effective in treating low back pain (Richardson *et al.,* 1999; Hides *et al.,* 2001). Thus, the results in the present study confirm this view. However, conservative programmes will not necessarily cause the improvement in the overall functional status that the more aggressive programmes might have.

There was no significant difference between the post-test scores of the control and experimental groups. However, even if functional status improvement is regarded as being more important than pain levels, pain should still be addressed as a primary outcome goal. It has been reported by Meyer (2007) that poorly controlled pain remains a world-wide problem. In 1998 a survey indicated that about 22% of patients in primary care reported persistent pain over the past year. They believed that their pain was not treated properly (Gurejo *et al.,* 1998; Meyer, 2007).

The importance of pain has increased tremendously over the past decade. Chronic pain as a whole, which includes chronic low back pain, is now seen as a disease itself and not only as a symptom. It has also been recognised as the so-called 'fifth vital sign' and should be monitored with the same vigilance as blood pressure, temperature, pulse and respiratory rate (Meyer, 2007). Thus, pain management should be of primary concern and is just as important as functional status.

There was no significant difference of the post-test measurement between the control and experimental groups for the TAMPA scale, as well as from pre-test to post-test between either group. The mean score of either of the two groups was very high at pre-test or differed significantly, indicating that this particular cohort of chronic low back pain patients did not harbour a very high fear of movement to begin with. Both groups improved but not significantly. The experimental group improved more than the control group, although not significantly. This result can partially confirm the success of the experimental group exercise programme.

However, it has been reported that very intensive multidisciplinary rehabilitation, such as more than a hundred hours is needed to achieve favourable results on those who are actively working (Kääpä *et al.,* 2006). It has been mentioned previously that all of the patients in the study were full working capacity adults and more active back school might have been more beneficial towards this variable. The experimental group received only 2.5 hours' worth of back school counselling.

Table 4.3 : Descriptive Statistics per Group on Pre-test and Post-test Measurements (continued)

Group		N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Oswestry Disability Index Pre-test	18	11	44	23.72	8.574
	Oswestry Disability Index week 4	12	2	30	15.42	7.416
	Oswestry Disability Index week 8	11	0	18	10.18	6.431
	Oswestry Disability Index week 12	11	0	20	8.00	7.376
	Functional Rating Index Pre-test	18	15	63	34.61	13.232
	Functional Rating Index week 4	12	0	38	19.58	9.307
	Functional Rating Index week 8	11	0	25	14.82	7.960
	Functional Rating Index week 12	11	0	25	10.64	8.686
	Valid N (listwise)	11				
Control	Oswestry Disability Index Pre-test	14	10	34	20.07	7.731
	Oswestry Disability Index week 4	13	6	42	19.69	10.379
	Oswestry Disability Index week 8	10	4	30	14.20	7.068
	Oswestry Disability Index week 12	10	2	20	11.00	6.200
	Functional Rating Index Pre-test	14	23	43	32.29	7.559
	Functional Rating Index week 4	13	13	48	27.00	8.972
	Functional Rating Index week 8	10	10	33	20.50	6.060
	Functional Rating Index week 12	10	3	23	13.80	6.233
	Valid N (listwise)	10				

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- Oswestry Disability Index and Functional Rating Index: The pre-test measurements were significantly higher than the post-test measurements.

This shows a favourable result for the present study, as a lower score shows an improvement in self-reported disability levels. A significant decrease in disability levels, as shown by the Oswestry Disability Index and the Functional Rating Index, demonstrates that an aggressive-progressive exercise programme may also be effective in decreasing levels of self-reported disability. Research has argued the importance of disability levels in chronic pain (Dionne *et al.,* 1995; Cherkin *et al.,* 1996; Waddell, 1996; Dionne *et al.,* 1997; Pfingsten *et al.,* 1997; Epping *et al.,* 1998; Thomas *et al.,* 1999; Linton *et al.,* 2000; Pincus *et al.,* 2002; Staal *et al.,* 2003; Staal *et al.,* 2005), as well as the need to reduce it (Ashburn & Staats, 1999; Sanders *et al.,* 1999; Simmonds & Dreisinger, 2003; Sanders *et al.,* 2005).

Linton *et al.* (2005) reported that it is possible to even prevent the development of pain-related disability by providing specific interventions, which focus on the psychosocial and functional troubles that patients find problematic. Any type of exercise programme that can reduce disability levels may be considered a worthwhile treatment modality, especially an aggressive-progressive type of exercise programme that may improve functional status in the long-term (Manniche *et al.,* 1991; Johannsen *et al.,* 1995; Petersen *et al.,* 2002; Ostelo *et al.,* 2003). This, in conjunction with high-intensity back school, has an overall improvement in low back outcomes.

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the control group:

- Oswestry Disability Index and Functional Rating Index: The pre-test measurement was significantly higher than the post-test measurement.

The control group also showed a good outcome in terms of disability variables. This shows that a conservative exercise programme is very effective in improving disability due to low back pain. It has been reported that physical exercise is recommended to prevent absence due to back pain and the occurrence or duration of further back pain episodes (Burton, 2005). Exercise therapy for chronic low back pain is recommended by several guidelines (Spitzer *et al.,* 1987; Albright, 2001; Hayden *et al.,* 2005; Krismer & Van Tulder, 2007).

Impaired function of trunk muscles has been shown to have a close correlation with the pathogenesis of chronic low back pain (Shirado *et al.,* 1992; Shirado *et al.,* 1995a; Ito *et al.,* 1996). The main purpose of therapeutic exercise is to strengthen trunk muscles and improve trunk flexibility (Shirado *et al.,* 1995b). Stabilisation exercises differ from general exercises by being more body-specific, and requiring more attention and precision from the patient (Bergmark, 1989a). This proves that a conservative exercise programme is still effective in improving levels of disability.

In both the Oswestry Disability Index as well as the Functional Rating Index the mean scores in the experimental group were lower than in the control group, but not significantly better. This could argue a better improvement in the experimental group. It could be due to the nature of the back school, which was more intensive than in the control group. The one-on-one sessions used in the experimental group could have had more of an improvement. The control group received only the textbook to read through on their own. The experimental group received the textbook as well as one-on-one attention about the contents. This type of counselling has been reported to be effective in the treatment of chronic low back pain (Tulder *et al.,* 2001).

However, the amount of back school intervention used in the present study was not in line with previously reported research. The Swedish approach of four sessions per week lasted around 30 minutes each (Heymans *et al.,* 2006). High intensity back schools used a twice-a-week approach for eight weeks. These consisted of 16 sessions, each lasting an hour (Vlaeyen *et al.,* 1995). It has also been reported that only very high-intensity multidisciplinary rehabilitation (>100 hours) can be effective for chronic low back pain (Guzman *et al.,* 2001).

The present study used 10 sessions lasting approximately 10 minutes each. It was expected that shorter sessions would not lead to boredom and lack of interest on the part of the patients. It has been reported previously that educational and exercise sessions require keen concentration and active participation, especially in those patients who work full-time (Kääpä *et al.,* 2006).

Patients in the experimental group expressed their gratitude on the educational sessions not being lengthy in duration, especially at the end of a long working day. Future research has to find a balance between sufficient time to convey enough information to not cause mental fatigue in patients, especially in those of full working capacity.

Table 4.4: Descriptive Statistics per Group on Pre-test and Post-test Measurements (continued)

Group		N	Minimum	Maximum	Mean	Std. Dev
Experimental	FABQ Pre-test Scale 1	18	0	26	9.61	8.052
	FABQ Pre-test Scale 2	18	0	20	12.11	5.940
	FABQ Pre-test Total	18	2	42	21.72	10.260
	FABQ Scale 1 week 4	12	0	19	6.58	5.616
	FABQ Scale 2 week 4	12	2	20	12.42	4.757
	FABQ Total week 4	12	0	36	19.00	8.975
	FABQ Scale 1 week 8	11	0	22	5.73	7.001
	FABQ Scale 2 week 8	11	0	15	8.09	5.375
	FABQ Total week 8	11	3	29	14.09	9.049
	FABQ Scale 1 week 12	11	0	24	6.27	8.113
	FABQ Scale 2 week 12	11	0	12	4.09	3.727
	FABQ Total week 12	11	1	24	10.36	7.877
	Valid N (listwise)	11				
Control	FABQ Pre-test Scale 1	14	0	28	12.64	10.035
	FABQ Pre-test Scale 2	14	1	24	14.29	5.663
	FABQ Pre-test Total	14	6	45	26.93	10.923
	FABQ Scale 1 week 4	13	0	30	9.69	9.277
	FABQ Scale 2 week 4	13	2	21	12.77	5.510
	FABQ Total week 4	13	11	51	22.46	11.801
	FABQ Scale 1 week 8	10	0	23	10.70	8.111
	FABQ Scale 2 week 8	10	3	18	11.10	4.358
	FABQ Total week 8	10	9	38	21.40	9.336
	FABQ Scale 1 week 12	10	0	21	6.40	7.877
	FABQ Scale 2 week 12	10	0	19	7.00	6.716
	FABQ Total week 12	10	0	40	13.40	12.176
	Valid N (listwise)	10				

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- FABQ Scale 2: The pre-test measurement was significantly higher than the post-test measurement.

In the Fear Avoidance Beliefs Questionnaire the second scale measured fears regarding work and its influence on pain and disability (Swinkels-Meewisse *et al.,* 2003). Working status is an important factor in the management of chronic low back pain (Pincus *et al.,* 2002). Work absenteeism plays an important role in the recovery of patients, and recurrences in pain can lead to recurrences in work absenteeism, as well as restrictions in usual activities (Hildebrandt *et al*., 2004; Katz, 2006). Especially when pain becomes long-standing it can lead to severe disability due to work absence and severe social consequences such as isolation (Punnett *et al.,* 2005). It is because of this that return to work has been recommended as an important goal in the management of chronic low back pain (Staal *et al.,* 2005).

However, in the present study, all of the patients were of full working capacity and nobody was absent from work for any amount of time due to their back pain. Staal *et al.* (2005) have proposed that while working, the disabled worker realises that he or she is still active despite being in discomfort. Being at work, in a partial or full capacity, draws the attention of the disabled worker away from negative issues such as pain and helps to decrease the focus of the disablement. This could provide an explanation to why the patients in the present study did not present with high levels of disability to start with, and why they are all of full working capacity status, even though many of them have been suffering from low back pain for many years.

Even after treatment the patients in the aggressive-progressive exercise group reported that they felt less fear about activities in their working lives and that they were able to perform certain activities with more confidence and less anticipation for developing pain. It has been reported that pain relief is not necessary to resume work in any case (Lindstrom *et al.,* 1995; Crombez *et al.,* 1999; Van Tulder *et al.,* 2000). This suggests a more subjective outlook on pain experienced by the patients. It could be argued that the programme instilled more confidence in the patients regarding their day-to-day working activities.

- FABQ Total: The pre-test measurement was significantly higher than the post-test measurement.

Fear of pain, as measured by the Fear Avoidance Beliefs Questionnaire, during an episode of back pain is related to chronic pain status at follow-up (Gatchel *et al.,* 1995; Klenerman *et al.,* 1995; MacFarlane *et al.,* 1999), making fear avoidance an important factor in the treatment of low back pain simply due to the fact that back pain can be trigger by psychological factors such as a fear of pain or illness (Carragee *et al.,* 2000).

It is reported that patients who perceive pain in a threatening, catastrophic manner are much more likely to experience pain-related fear and anxiety, and consequently to engage in escape or avoidance behaviours to situations that they perceive to be potentially harmful (Thomas & France, 2007). Over time avoidance of these activities of daily living that are perceived to increase pain or risk for re-injury, is repeatedly reinforced by anxiety reduction. Hence, pain-related fear and anxiety ultimately contribute to symptoms of disuse and disability (Thomas & France, 2007).

It has also been suggested that fear avoidance beliefs for physical activity follow the same clinical pattern as pain and related disability (Grotle *et al.,* 2006). This even has a physical component in that guarded movements and hyperactivity in the lumbar paraspinal muscles are correlated with pain-related fear (Maffey-Ward *et al.,* 1996; Main & Watson, 1999). It can thus be argued that pain and fear avoidance behaviour will contribute to disability along with work absenteeism, causing a cycle that will ultimately lead to severe forms of disability and activity restriction.

Exercise has an important role to play in the management of fear avoidance behaviour. It has been suggested that exercise could have a therapeutic effect by improving physical function impaired by chronic back low pain, improving back pain intensity and improving disability through a process of desensitisation of fears and concerns, altering pain attitudes and beliefs (Rainville *et al.,* 2000).

This was the goal of the back school used in the present study in conjunction with the exercise programme, namely to eliminate fears regarding pain, as well as any resulting disability caused by pain and its related fear. It has been shown that fear avoidance beliefs are significantly more reduced in patients who are provided with cognitive intervention and exercise (Brox *et al.,* 2003). The result from the current study confirms this finding. An aggressive-progressive exercise programme, in conjunction with high-intensity back school, can help decrease pain-induced fear avoidance behaviour in those suffering from chronic low back pain. It will ultimately decrease overall disability caused by chronic low back pain.

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the control group:

- FABQ Scale 1, FABQ Scale 2 and FABQ Scale Total: The pre-test measurements were significantly higher than the post-test measurements.

The control group programme was also very effective in decreasing the amount of fear avoidance the patients experienced. As has been reported previously, exercise has an important role to play in the management of fear avoidance behaviours. It has been suggested that exercise could have a therapeutic effect by improving physical function impaired by chronic back low pain, improving back pain intensity and improving disability through a process of desensitisation of fears and concerns, altering pain attitudes and beliefs (Rainville *et al.,* 2000).

This was the goal of the back school used in the present study in conjunction with the exercise programme, namely to eliminate fears regarding pain, as well as any resulting disability caused by pain and its related fear. It has been shown that fear avoidance beliefs are significantly more reduced in patients who are provided with cognitive intervention and exercise (Brox *et al.,* 2003). However, the back school used in the control group was very low intensity. Patients were only given the textbook to read on their own. Some of the patients admitted that they never read through the book. This could question the effectiveness of the back school, as the control group also showed significant improvements in not only fear avoidance beliefs, but also in disability variables.

The reason for the improvement in the variables of the control group could be that the exercise programme has more than just a physical strengthening effect. It could be that the patients can observe their own physical improvement over the 12 weeks and then realise that they are more capable than they previously believed. This could then lead to more confidence in previously avoided activities in both personal and occupational settings. The back school could thus reaffirm their confidence in line with their own observations of feeling less scared to move more and be more active.

There was no significant difference found between the experimental and control groups at post-test level for the Fear Avoidance Beliefs Questionnaire (FABQ) for any of the scales.

This result questions the effectiveness of the high-intensity back school used in the experimental group. It was expected to be more significantly effective than the low-intensity back school used in the control group. This again only partially confirms the hypothesis of the study because the experimental group was only slightly more effective. The high-intensity back school was certainly effective, as was shown by the results from pre-test to post-test. In the high-intensity back school approach the confrontational method to pain management was used, as suggested by Lethem *et al.,*(1983).

However, an exercise intervention method uses this approach by default, as it challenges the fear of movement that patients could have (Vlaeyen & Linton, 2000). The back school could reaffirm this new belief and confidence to move and to be active. This could be the reason why there was a small difference between the experimental and control groups' back schools. The exercise programmes achieved most of the effect, as it challenged the patients to be active in a way that they did not think possible. To achieve a better result from the back school it might be more effective to identify patients who would benefit more from a cognitive intervention strategy, as proposed by Kääpä *et al.* (2006).

Table 4.5: Descriptive Statistics for the Experimental Group on Questionnaire Measurements

Group		N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Cycling Program 1	11	6	12	8.09	2.212
	Cycling Program 2	11	6	14	9.00	2.864
	Cycling Program 3	11	6	17	9.91	3.754
	Lat Pulldown Program 1	11	6	12	9.18	2.183
	Lat Pulldown Program 2	11	6	14	10.27	2.936
	Lat Pulldown Program 3	11	7	17	11.36	2.908
	Cable Excercise Program 1	11	5	13	9.18	2.316
	Cable Excercise Program 2	11	6	18	11.64	4.007
	Cable Excercise Program 3	11	6	13	9.36	2.580
	Valid N (listwise)	11				

Tables 4.5 and 4.6 measured the results from the Borg Rate of Perceived Exertion(RPE) scale. None of the results differs significantly. At best there is a small increase from the first exercise through to the third exercise. This suggests that there were small increases in intensity between each successive exercise, except for the Cable Exercise 2, which achieved a higher score than Cable Exercise 3. This indicates that it would have been better to have had Cable Exercise 2 in the third programme rather than the second programme. These results show a progressive increase in exercise intensity between the programmes. The exercises were thus ideal for the programmes in their progression stages.

Table 4.6: Descriptive Statistics for the Experimental Group on Questionnaire (continued)

Group		N	Minimum	Maximum	Mean	Std. Dev.
Experimental	Side Bridging Program 1	11	7	20	12.09	3.859
	Side Bridging Program 2	11	7	20	13.27	3.875
	Side Bridging Program 3	11	9	20	14.64	3.384
	Hip Lifts Program 1	11	9	14	11.73	1.489
	Hip Lifts Program 2	11	10	19	13.00	2.966
	Hip Lifts Program 3	11	9	15	12.45	1.809
	Alt Superman Program 1	11	7	15	10.82	2.676
	Alt Superman Program 2	11	7	14	11.09	2.427
	Alt Superman Program 2	11	7	15	11.64	2.693
	Abdominal Crunch Program 1	11	9	16	12.18	2.089
	Abdominal Crunch Program 2	11	9	16	12.91	1.921
	Abdominal Crunch Program 3	11	12	18	14.82	1.888
	Valid N (listwise)	11				

The results from Table 4.6 show a very similar tendency as Table 4.5, because there is a small increase in exercise intensity throughout the stages of progression. Only Hip Lifts Programme 2 showed a higher score than the exercise of the third programme (Hip Lifts Programme 3). Thus, it would have been better to have had that exercise rather in the third programme, and Hip Lifts Programme 3 in the second programme.

The concept of using an RPE scale has been investigated in the past. Barker *et al.* (2003) used an RPE scale to measure the intensity of aerobic exercise in patients with chronic low back pain when performing exercise in a hydrotherapy pool. They found that at workloads sufficient to induce an aerobic training response and still safe for the patients, the rate of perceived exertion was an accurate predictor of exercise intensity. Unfortunately it is difficult to compare the results from the present study with those from the Barker *et al.* (2003) study, as they used heart rate to compare with perceived intensity.

They also compared it with aerobic fitness levels. The present study did not measure heart rate at any stage during the study and it was never sought to increase the heart rate of the patients in order to gain aerobic fitness. The rate of perceived exertion scale was only used to measure the perceived intensity of the performed exercises in order to gain insight into their difficulty in performing for those with chronic low back pain.

Wallbom *et al.* (2002) also used physiological parameters to compare with rate of perceived exertion scales. It was found that a percentage of maximum heart rate is significantly related to self-reported pain and disability, as well as age. It is suggested that perceived exertion in populations with disabling back pain is not highly correlated with physiologic effort, as other factors such as pain may influence effort rating (Wallbom *et al.,* 2002). Again physiological parameters were not measured in the present study to be able to compare it with the other findings.

However, just like in the Wallbom *et al.* (2002) study, it was found in the present study that physiological exertion was not necessarily the limiting factor, but pain probably was more so. It is thus unclear if patients with chronic low back pain rate the intensity of the exercises according to physiological effort or pain. Much more research will be needed in future if a rate of perceived exertion scale is to be used for patients with chronic low back pain.

4.5.2 Frequency, Intensity and Duration

In terms of frequency, intensity and duration it is recommended that for frequency 2-3 times per week is sufficient (Manniche *et al.,* 1991; Oldridge & Stoll, 1997; Perkins & Zipple, 2003). Both the control and experimental groups performed their programmes twice per week in line with the recommendation. However, it is suggested that in early rehabilitation exercises should be performed daily with decreasing frequency as exercise tolerance increases. None of the patients in the study had ever participated in a low back rehabilitation programme up to the point of the intervention. A case could be made for rather performing the exercises daily, but it was decided to keep to two sessions per week to ensure supervision. Patients were not able to attend every day and the decision to supervise was decided to be more important.

The intensity of the exercise programmes, specifically for those with chronic low back pain, is more difficult to determine, as clear instructions are difficult to obtain. Available instructions usually suggest that the exercise prescribed should be more intense than that normally prescribed for back patients (Perkins & Zipple, 2003). The reason for this could be the necessity to increase functional ability, as those with chronic low back pain tend to become more disabled with time (Bergquist-Ullman & Larsson, 1977). One set of instructions, described as the Delorme method for intensity selection, suggests selecting resistance that allows 20-30 repetitions with proper neuromuscular control in a pain-free or minimal painful range of motion (Perkins & Zipple, 2003). Initially this will increase endurance and control of movement. As the person progresses, resistance should be increased while the number of repetitions decreased to 8-12, which is comparable with ACSM strength training guidelines (ACSM, 2000).

Self-selected intensity or exercise to pain tolerance often leads to inadequate exercise levels. Although pain might not improve for several months in many patients, an intensive exercise programme may result in greater functional and psychological benefits than a less aggressive approach (Perkins & Zipple, 2003).

Others also suggest a quota approach, in which exercise intensity is prescribed to prevent under-exercising (Lindstrom *et al.,* 1992; Linton, 1994; Rainville *et al.,* 1997). This lends support for the use of a more aggressive exercise programme as used in the present study to focus on more issues relating to chronic low back pain than only subjective pain levels.

Also, the present study attempted to use the Borg RPE scale to measure the intensity of the experimental group. The results show slight progressing in most exercises throughout the three training programmes. It shows sufficient exercise intensities to promote a training effect, but was not too strenuous at any stage that the danger of injury existed.

However, the present study failed to measure the control group by means of the RPE scale, which will place a limitation on the results of the experimental group because the two groups cannot be compared on this variable. Future studies should further investigate the use of this scale in patients with chronic low back pain and to determine whether this is a viable scale to use in rehabilitation for this population group.

In terms of duration it is recommended that a training session lasts for between 20-30 minutes of aerobic exercise and weight training of 30-60 minutes (ACSM, 2000). However, it was felt that this recommendation is too lengthy for rehabilitation. The entire training session of the control group lasted only 35 minutes. The group's only form of aerobic training was in the warm-up exercise that lasted for only five minutes.

The experimental group also did only five minutes, but their cycling increased in intensity throughout the entire programme. The rationale behind this was that the goal of the rehabilitation programme was to first and foremost help the patients with their back pain. It was instructed to them to initiate exercise programmes after the intervention period consisting of longer duration and higher intensity. As the patients started to feel improvement during the study, many of them became more motivated to start with more difficult exercise programmes. All patients received guidelines of exercises to perform after the intervention period.

Table 4.7: Descriptive Statistics for the Experimental and Control groups (continued)

Group		N	Minimum	Maximum	Mean	Std. Dev.
Experimental	Pre-test Straight leg rise Neural Tension Left	20	1	2	1.90	.308
	Pre-test Straight leg rise Neural Tension Right	18	1	2	1.83	.383
	Pre-test Straight leg rise Hamstring Degree Left	18	46	110	67.17	16.660
	Pre-test Straight leg rise Hamstring Degree Right	18	22	90	65.28	16.215
	Post-test Straight leg rise Neural Tension Left	11	1	2	1.64	.505
	Post-test Straight leg rise Neural Tension Right	11	1	2	1.82	.405
	Post-test Straight leg rise Hamstring Degree Left	11	65	92	79.55	8.335
	Post-test Straight leg rise Hamstring Degree Right	11	70	101	82.82	10.685
	Valid N (listwise)	11				
Control	Pre-test Straight leg rise Neural Tension Left	15	1	2	1.73	.458
	Pre-test Straight leg rise Neural Tension Right	14	1	2	1.57	.514
	Pre-test Straight leg rise Hamstring Degree Left	14	44	98	74.29	15.107
	Pre-test Straight leg rise Hamstring Degree Right	14	39	87	68.36	15.540
	Post-test Straight leg rise Neural Tension Left	10	1	2	1.80	.422
	Post-test Straight leg rise Neural Tension Right	10	1	2	1.70	.483
	Post-test Straight leg rise Hamstring Degree Left	10	68	94	83.50	7.778
	Post-test Straight leg rise Hamstring Degree Right	10	69	92	79.80	8.728
	Valid N (listwise)	10				

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- Straight Leg Rise Hamstring Degree Left and Right: The post-test measurements were significantly higher than the pre-test measurements.

It has been shown that patients with a history of low back pain have reduced hamstring flexibility (Biering-Sorensen, 1984). The aggressive-progressive exercise programme contained stretching exercises that were selected to improve hamstring flexibility. This was selected because of the effect of the hamstring muscles on low back posture. Tight hamstrings are prominent in postures such as flat-back and sway-back postures (Kendall *et al.,* 1993). These types of postures have been associated with back pain in the past, and by stretching these muscles pressure on the low back may be alleviated by correcting possible imbalances due to postural faults (Kendall *et al.,* 1993). However, the limited available data does not support the view that greater flexibility of the spine prevents injury, but it is important to maintain adequate flexibility at the hips and knees for lifting (Perkins & Zipple, 2003). This supports the motivation for performing stretches that involve not only the hamstrings, but also the quadriceps muscle group, as well as the buttocks and hips, as was performed by the experimental group.

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the control group:

- Straight Leg Rise Hamstring Degree Right: The post-test measurement was significantly higher than the pre-test measurement.

There was a decrease in both legs in this group for this value. The control group performed a hamstring stretching exercise that was much simpler than that of the experimental group. The exercise also stayed the same throughout the 12 week intervention period. The exercise was selected due to its conservative non-threatening application. However, this result indicates the shortcoming of this exercise in terms of being insufficient when strengthening exercises are also involved.

The control group performed many exercises than involve and ultimately strengthen the hamstring muscle group (e.g. hip lifts), just like the experimental group. Skeletal muscles adapt their length and stiffness according to the functional demands to which they are regularly submitted. This modification of muscle stiffness and length induced by resistance training may alter the joint stiffness and theoretically change the joint resting position (Ocarino *et al.,* 2008). This indicates the necessity of a more aggressive type of stretching exercise to ensure that the hamstring muscle group retains its mobility. As has been discussed, it is very important to maintain the flexibility of the hamstrings to ensure functional activities are performed with maximum ease (Perkins & Zipple, 2003).

Statistically significant differences at the 5% level of significance were found between the post-test measurements of the experimental and control groups of the following:

- Straight Leg Rise Hamstring Degree Right: The post-test value of the experimental group was significantly higher than that of the control group.

This result is to be expected due to the fact that the experimental group had many more exercises that were selected to increase the flexibility of the hamstring muscles. The reason that this result was only found on the right side could be due to the dominant side being preferred by the patients and thus more effort was applied. At the post-test all of the patients remaining in the study reported being right side dominant (89%).

Table 4.8: Descriptive Statistics for the Experimental and Control groups (continued)

Group		N	Minimum	Maximum	Mean	Std. Dev.
Experimental	Pre-test Slump test Left	18	1	2	1.39	.502
	Pre-test Slump test right	18	1	2	1.17	.383
	Post-test Slump test Left	11	1	2	1.36	.505
	Post-test Slump test Right	11	1	2	1.36	.505
	Valid N (listwise)	11				
Control	Pre-test Slump test Left	14	1	2	1.43	.514
	Pre-test Slump test right	14	1	2	1.29	.469
	Post-test Slump test Left	10	1	2	1.20	.422
	Post-test Slump test Right	10	1	2	1.30	.483
	Valid N (listwise)	10				

The slump test was performed at pre-test and at post-test evaluation. This test is designed to place the Sciatic nerve under increasing levels of tension (Majlesi *et al.,* 2008). The test applies traction to the nerve roots by incorporating spinal and hip flexion into leg raising and warns of the presence of nerve root compression (Majlesi *et al.,* 2008). However, the results from the slump test are too varied and no consistent pattern emerged; thus, no conclusion can be drawn other than that there was no indication of nerve root compression.

The value of the slump test was that it was used to assist in eliminating any possible ‘red flag’ conditions. No patient tested either at pre-test or post-test presented with any symptoms such as sciatic pains or worsening of back pain. All of the discomfort felt, only indicated hamstring tightness or neural tension. All tension was relieved when cervical extension was added. Relief or partial relief following cervical extension indicates a normal response to the slump test. It may thus be considered to be a neurogenic response (Walsh *et al.,* 2007). No patient was unable to have the test performed on him and none showed lasting symptoms afterwards.

Table 4.9: Descriptive Statistics for the Experimental and Control Groups (continued)

Group		N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Pre-test Modified Sorenson Test	18	8	180	69.17	46.732
	Post-test Modified Sorenson Test	11	31	240	138.82	73.929
	Pre-test Side Bridging Left	18	0	92	30.61	23.553
	Pre-test Side Bridging Right	18	2	96	34.78	25.917
	Post-test Side Bridging Left	11	30	180	73.00	44.215
	Post-test Side Bridging Right	11	17	180	71.45	44.098
	Pre-test 60 degree Flexor	17	19	180	89.71	66.987
	Post-test 60 degree Flexor	11	39	240	151.09	70.438
	Valid N (listwise)	11				
Control	Pre-test Modified Sorenson Test	14	0	114	47.57	30.686
	Post-test Modified Sorenson Test	10	25	180	112.00	57.417
	Pre-test Side Bridging Left	14	5	49	27.71	11.964
	Pre-test Side Bridging Right	14	6	48	27.14	12.799
	Post-test Side Bridging Left	5	13	43	29.20	13.349
	Post-test Side Bridging Right	5	13	48	28.60	12.896
	Pre-test 60 degree Flexor	14	21	114	71.64	31.402
	Post-test 60 degree Flexor	10	45	240	114.60	63.479
	Valid N (listwise)	5				

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.

This was an excellent result for the present study. Research demonstrated the importance of the low back extension musculature in low back pain research and also predicted low back pain prevalence (Biering-Sorensen, 1984; Adams *et al.*, 1999; Sjolie & Ljunggren, 2001; McGill, 2002; Demoulin *et al.,* 2004). The fact that this group was able to increase their back extensor endurance values has important implications for the future. For one, it has shown that the patients in the experimental group decreased their chances for future episodes of low back pain, as described by Biering-Sorensen (1984). By increasing their extensor muscle endurance, the patients gained protection against external loads by increasing the load-bearing ability of the extensor muscle.

A positive aspect of the aggressive-progressive group was that it increased the extensor muscle endurance and the overall functional ability of the patients, as well as decreasing pain levels. These three aspects have to be considered the three most important outcomes when dealing with chronic low back pain. All three aspects have been described in the literature in great detail, and have to be considered in both research and the private setting. However, all of the involved musculature have to be considered in low back pain research (extensor, flexor and lateral musculature) and not only the extensor group (McGill, 2002).

Also, at pre-test many patients reported that they had stopped because of pain, but those who stopped at the post-test reported fatigue as the limiting factor. As described by others, pain may be the reason why patients choose to terminate the test and not necessarily because of muscular fatigue (Biering-Sorensen, 1984; Mannion & Dolan, 1994; Latikka *et al.,* 1995; Moreland *et al.,* 1997; Latimer *et al.,* 1999). This finding was also reported in the present study. Pain was still reported by some patients at post-test, but pain reported was minimal and not stated as the reason for terminating the test. Only when the patients decreased their fear avoidance beliefs as well, were they able to sustain the test beyond pain levels and to the point of muscular fatigue.

It has been reported that shorter holding time in patients with a history of low back pain may reflect test fear avoidance behaviour (Waddell *et al.,* 1993). No patients in either of the two groups reported increased levels of pain or discomfort when they completed the extension test. It can also then be argued that pain apprehension and not true reflected levels of pain were the limiting factors in the present study. It has been suggested that those with a history of low back pain tend to have shorter holding times (Ropponen *et al.,* 2005). It has been suggested that those with daily low back pain are much more likely to stop the test due to pain. The clinical implication would suggest that the isometric back extension endurance test might reflect current back symptoms and pain tolerance of those with daily low back pain history more than it serves as a measure of physical capacity such as isometric back endurance (Ropponen *et al.,* 2005).

Subjective pain experience again plays an important role. Thus, at post-test patients could extend themselves without the fear of causing increased damage to themselves. This phenomenon was also reported to the patients who then realised that they were not limited by their current pain levels but rather by fear avoidance beliefs. This also served as proof to the patients that they were capable of more functional capacity than they initially believed even though minimal levels of pain were still present.

The aggressive-progressive exercise programme was able to decrease pain levels significantly, and increase the strength endurance of the extensor muscles and the functional ability of the patients. This is in accordance with other researchers who have suggested that patients with low back pain should gain from somewhat higher intensity of exercise than commonly used (Mayer *et al.,* 1985).

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the control group:

- Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the control group.

The control group performed exercises that are traditionally done for low back pain, especially McKenzie-based extension movements. These types of back extension movements are often suggested for strengthening the erector spinae muscles (D'Orazio, 1999). Recommended exercises included the alternative superman exercise (Perkins & Zipple, 2003), which was performed by both the control and experimental group. This exercise has been suggested to produce low levels of spine compression and is relatively safe for those suffering from chronic low back pain (Perkins & Zipple, 2003). Because the control group performed this exercise in its most basic form (on all fours), this version is probably safer than the exercise versions performed by the experimental group.

No significant difference was found between the post-test values of the control and experimental groups.

The mean score in the experimental group was higher than that of the control group. This again partially confirmed the hypothesis of the study in which the experimental variable was higher than that of the control, although not significantly. However, this result could have been expected, as both groups concentrated on performing extension based exercises that were expected to increase this variable. The improved difference seen in the experimental group may be attributed to the other exercises included in the programme. These had more of a combined effect than the extension-based exercises alone.

The control group performed exercises that are traditionally done for low back pain, especially McKenzie-based extension movements. These types of back extension movements are often suggested for strengthening the erector spinae muscles (D'Orazio, 1999). Recommended exercises included the alternative superman exercise (Perkins & Zipple, 2003), which was performed by both the control and experimental group. This exercise has been suggested to produce low levels of spine compression and is relatively safe for those suffering from chronic low back pain (Perkins & Zipple, 2003). Because the control group performed this exercise in its most basic form (on all fours), this version was probably safer than the exercise versions performed by the experimental group.

However, the results from the extension exercises have to be interpreted with caution. It has been reported that when the time to endurance limit is used as the measure of muscle fatigability, the termination of the test is strongly dependant on the patient's motivation and current levels of low back pain rather than actual muscle fatigability (Ropponen *et al.,* 2005). This is where fear avoidance behaviour plays an important role, because it may determine the extent to which a patient is prepared to exert himself.

Also, chronic low back pain patients active in working life do not tend to show any impairment in paraspinal muscle function or fatigability during dynamic endurance tasks (Kankaanpää *et al.,* 2005). As all of the patients in the present study were of full working capacity, it can be assumed that the main motivator for test termination can be related to fear avoidance behaviour and apprehension, and not necessarily pain.

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables in the experimental group:

- Side Bridging Left and Right: The post-test measurement is significantly higher than the pre-test measurement in the experimental group.

This result shows the success of the progression of the side bridging exercises in the experimental group. The importance of the lateral musculature has been shown in the literature (McGill, 1991; McGill, 1992; Juker *et al.,* 1998), especially since the obliques seem to be involved in stabilisation as well as movement (Belen'kii *et al.,* 1967; Bouisset & Zattara, 1981; Zattara & Bouisset, 1988; Aruin & Latash, 1995; Todorov & Jordan, 2002; Granada & England, 2006). The side bridging exercise has been shown to optimally activate the internal and external obliques, while placing minimal loads on the lower back but still provides enough stimuli to effectively train the muscles (Juker *et al.,* 1998; McGill, 1998; McGill, 2002).

The side bridging exercise also has the added advantage of training the quadratus lumborum, which is an important lumbar stabiliser (Perkins & Zipple, 2003). For example, during the second progression version of the side bridging exercise in which the patients performed the exercise with straight legs and holding the position static, the lumbar compression was a modest 2500N. However, the quadratus lumborum and the oblique closest to the floor appeared to be active up to 50% of the maximal voluntary contraction (MVC) (McGill, 2002).

There was no significant difference between the pre-test and post-test values for the left and right side bridging test in the control group.

This result was expected, as the control group performed no exercises to strengthen the lateral musculature. Due to the nature of the importance of the lateral musculature exercises to strengthen this component had to be included. Exercise with low levels of compressive force had to be included to achieve a total strengthening of all the important abdominal muscles.

Statistically significant differences at the 5% level of significance of the following were found between the post-test measurements of the experimental and control groups:

- Side Bridging Left and Right: The post-test values of the experimental group were significantly higher than those of the control group.

This is an important result due to the nature of the design of the programmes. The experimental group programme contained exercises that are used to strengthen the lateral musculature of the trunk, while the control group programme contained no exercises to strengthen this component. The different versions of the side bridging exercise used in the experimental group have been reported to be very effective exercises to strengthen the lateral trunk musculature with minimal compressive force penalty on the lower back (McGill, 2002). That is the reason for selecting this specific exercise.

It has been reported that a modification to the abdominal crunch could target the rectus abdominis, and the external and internal obliques, as well as the transversus abdominis by drawing the navel down towards the floor while performing the abdominal crunch (Karst & Willett, 2004). This was part of the instructions provided to patients when stabilising. By thus drawing in the navel they could activate the obliques, as well as the transversus abdominis in one exercise instead of having to do several exercises for each muscle group. This could be an important considering factor when time and patient compliance become issues.

The patients in the control group were not actively taught to stabilise like the experimental group. They had to read it in the back school document. Only two patients from the control group requested further explanation on the specific technique. It is thus unlikely that all patients in the control group performed the navel drawing-in technique. This fact may also explain the lack of improvement in the control group for the lateral musculature besides not performing any specific exercises of the lateral musculature. The experimental group performed the abdominal crunch with the naval drawing-in technique and could thus increase the amount of strengthening in the lateral musculature tests.

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- Sixty Degree Flexor: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.

This result was expected due to the nature of the design of the experimental group exercise programme. One exercise was used throughout the programme with the only difference being that it was progressed in terms of difficulty by adding an unstable surface and/or adding more repetitions. The test itself has been shown to be relatively safe for those with chronic low back pain (McGill, 2002) and no patients reported that they felt discomfort and/or pain after completion of the test.

Comparing the test and the exercise might be considered a weakness of the present study due to the fact that the test itself is an isometric test emphasising time and the exercise was a dynamic movement that emphasised repetitions performed. It has been shown that the rectus abdominis flexes the trunk (McGill, 2002), but also seems to have a function of stability (Friedli *et al.,* 1988; Zattara & Bouisset, 1988; Aruin & Latash, 1995). It has also been shown to be the most active muscle during sit-ups and curl-up exercises (Juker *et al.,* 1998). This shows that the exercise selected was the correct one for the goal in mind. Here it might have been more appropriate to have selected a dynamic test to compare with dynamic movements, or to have selected an isometric test to compare with an isometric exercise. However, there was a significant improvement in the result of this test, suggesting that the isometric-dynamic combination of testing and exercise still show significant improvements in pain and disability, as shown by the pain and disability results.

Also, patients in the experimental group were instructed to perform the abdominal exercise with lumbar stabilisation. This had the added effect of stabilising the pelvis, thus promoting lumbopelvic neuromuscular control, which maintained the neutral curve in the low back (Perkins & Zipple, 2003).

There was no significant difference between the pre-test and post-test values in the control group for this variable.

This result was expected due to the fact that the control group programme contained no specific exercise to increase abdominal strength. This might be considered a weakness of the present study. The importance of the abdominal muscles has been discussed previously and specific but safe exercises have to be included in any back rehabilitation programme. There was a degree of strengthening involved, but this could be the consequence of other exercises requiring abdominal activation and thus strengthening the abdominal muscles.

There was no significant difference between the control and experimental groups at post-test for this variable.

This again showed the effectiveness of the experimental exercise programme. It improved more than the control group for this value, though not significantly.

No statistically significant difference was found between any of the other post-test measurements between the experimental and control groups.

It can therefore be concluded that, as far as the post-test measurements are concerned, the two groups were very similar regarding the latter variables. This result only partially confirms the hypothesis of the study, which stated that the aggressive-progressive exercise programme would lead to more of an improvement in low back pain variables than a more conservative exercise programme.

The results were very similar for the two programmes. Both groups improved significantly, which was a good result for the study, but it was hoped that the aggressive-progressive group would improve more. More aggressive types of exercise programmes have been used for low back pain in the past (Manniche *et al.,* 1991; Johannsen *et al.,* 1995; Hartigan *et al.,* 2000; Petersen *et al.,* 2002). Results have shown that pain and disability decrease, and functionality increases with more intensive exercise programmes (Hartigan *et al.,* 2000).

It has been argued that it is more important to focus on the consequences of pain rather than focusing only on pain treatment (Staal *et al.,* 2005). This argues in favour of more aggressive exercise treatments, which will help to improve functional status because it will include more exercises than merely just stabilisation exercises. More aggressive types of exercise programmes will not necessarily be more harmful to the low back (Videman *et al.,* 1995) if the programme is designed sensibly and scientifically.

Table 4.10: Neuropathic Pain Results

	N	Mean
Neuropathic Pain Score (DN4)	15	1.4

According to the DN4 questionnaire a score of 4 and higher is a positive indication of neuropathic pain. The mean score was only 1.4, indicating that the sample did not have a neuropathic pain component. However, the important implication that neuropathic pain has, has been realised in recent years (Meyer, 2007). More research is needed on this topic, especially with regard to exercise and a possible treatment option for exercise.

4.5.3 Results of Differences Between Experimental and Control Groups on Pre-test Measurements

Results are summarised in Figure 4.1 to 4.4.

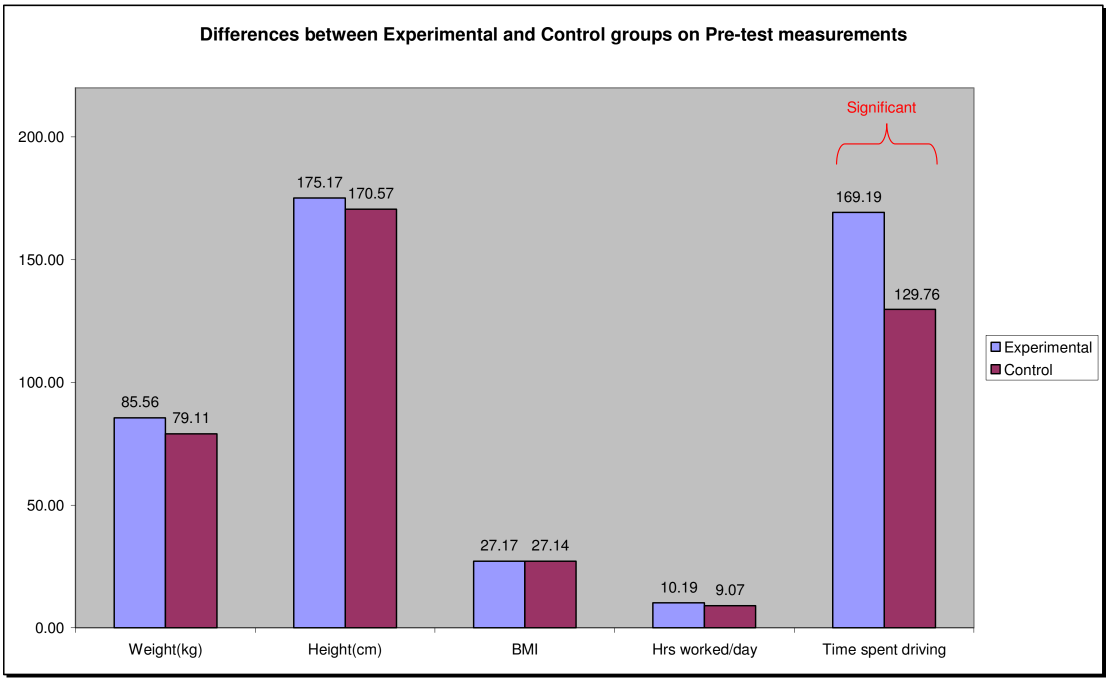


Figure 4.1: Difference Between Experimental and Control Groups on Pre-test Measurements

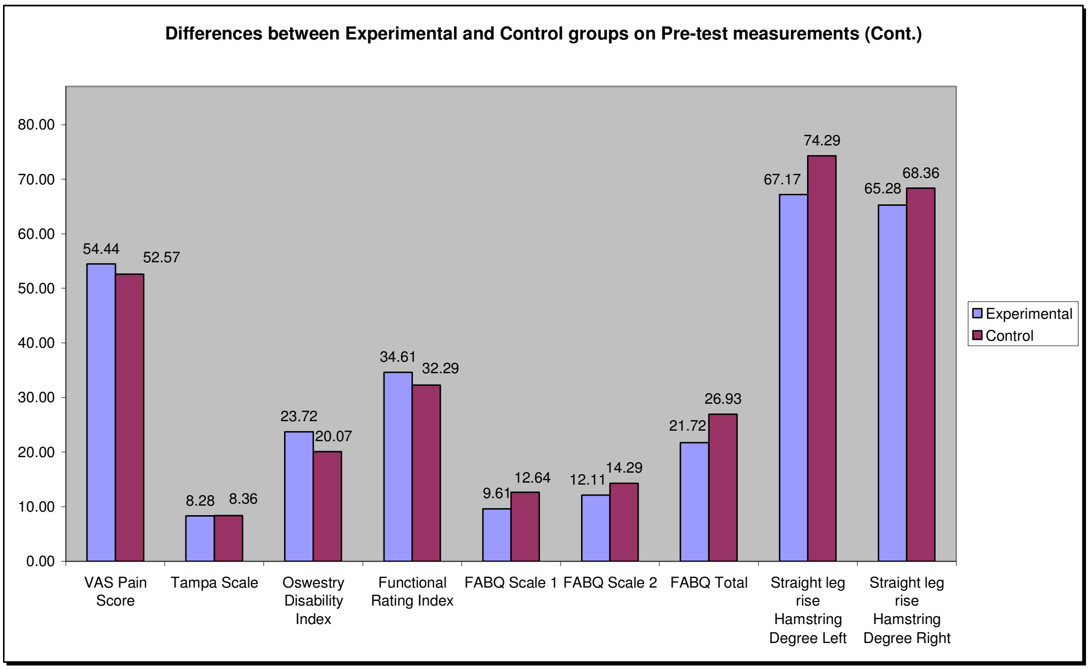


Figure 4.2: Difference Between Experimental and Control Groups on Pre-test Measurements (continued)

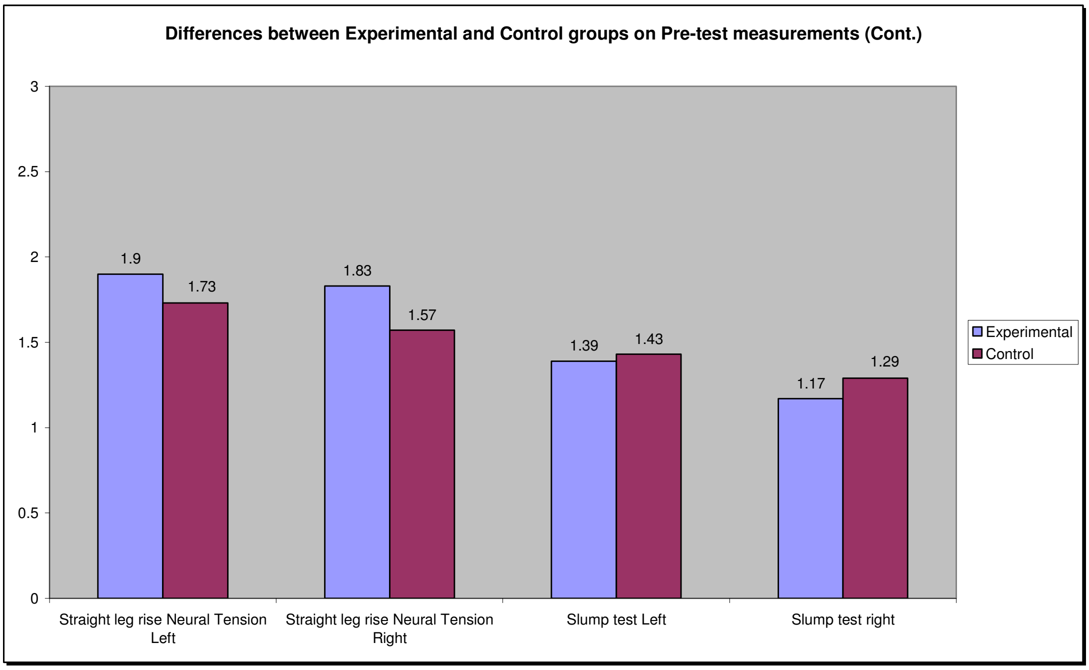


Figure 4.3: Difference Between Experimental and Control Groups on Pre-test Measurements (continued)

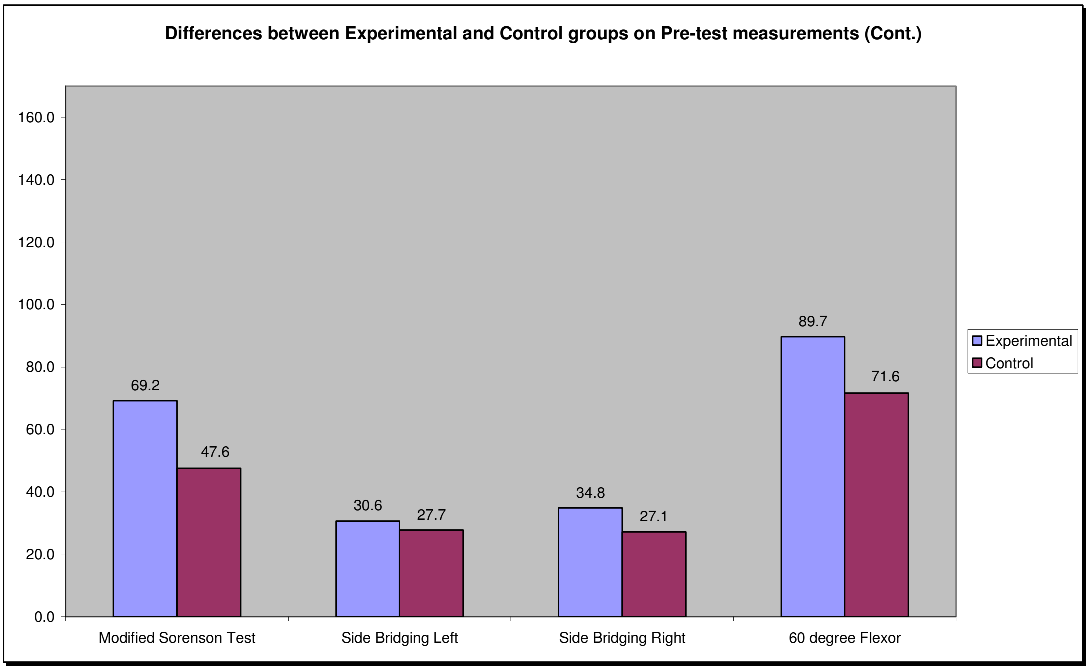


Figure 4.4: Difference Between Experimental and Control Groups on Pre-test Measurements (continued)

4.5.4. Results of Differences Between Experimental and Control Groups on Post-test Measurements

Statistically significant differences at the 5% level of significance of the following were found between the post-test measurements of the experimental and control groups:

- Straight Leg Rise Hamstring Degree Right: The post-test value of the experimental group was significantly higher than that of the control group.
- Side Bridging Left: The post-test value of the experimental group was significantly higher than that of the control group.
- Side Bridging Right: The post-test value of the experimental group was significantly higher than that of the control group.

No statistically significant difference was found between any of the other post-test measurements between the experimental and control groups. It can therefore be concluded that, as far as the post-test measurements are concerned, the two groups were very similar for the latter variables. Results are summarised in Figures 4.5 to 4.7 that follow.

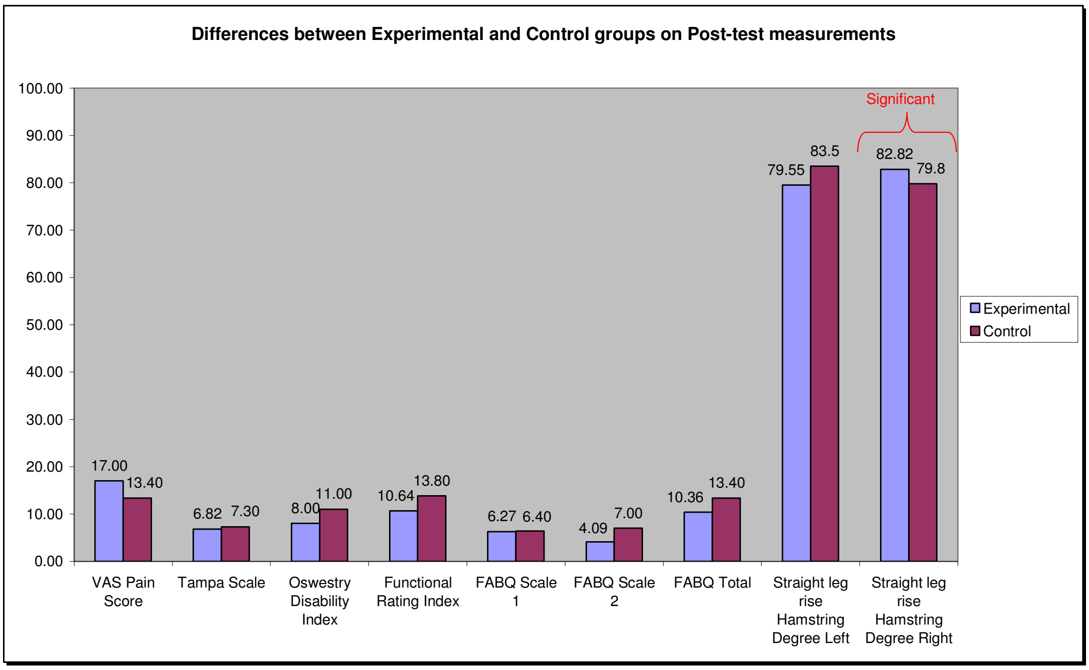


Figure 4.5: Difference Between Experimental and Control Groups on Post-test Measurements

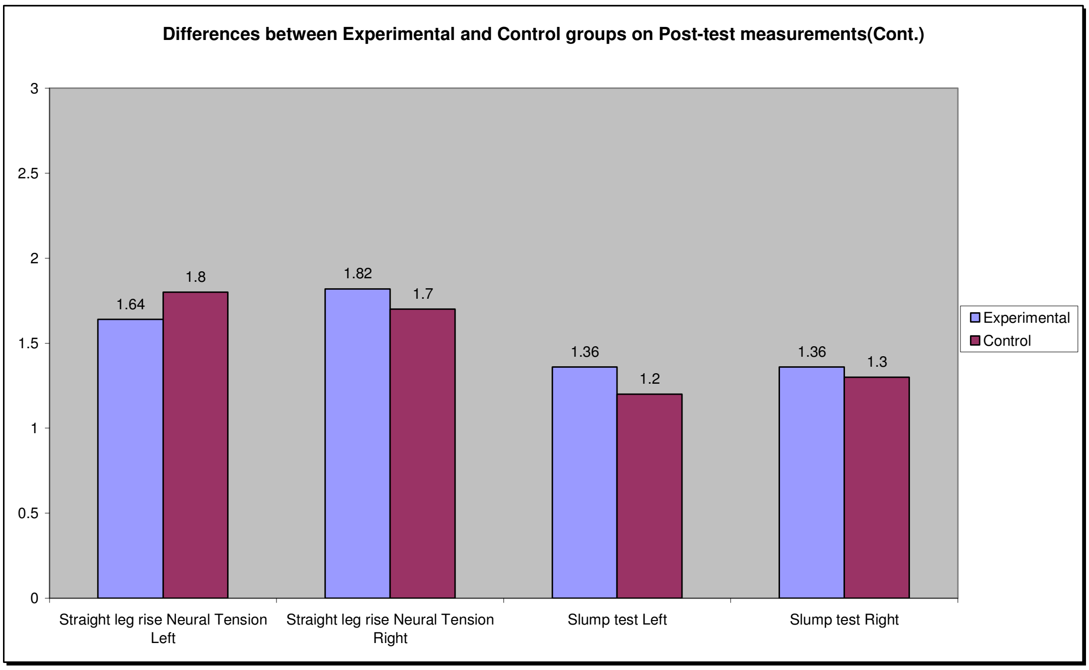


Figure 4.6: Difference Between Experimental and Control Groups on Post-test Measurements (continued)

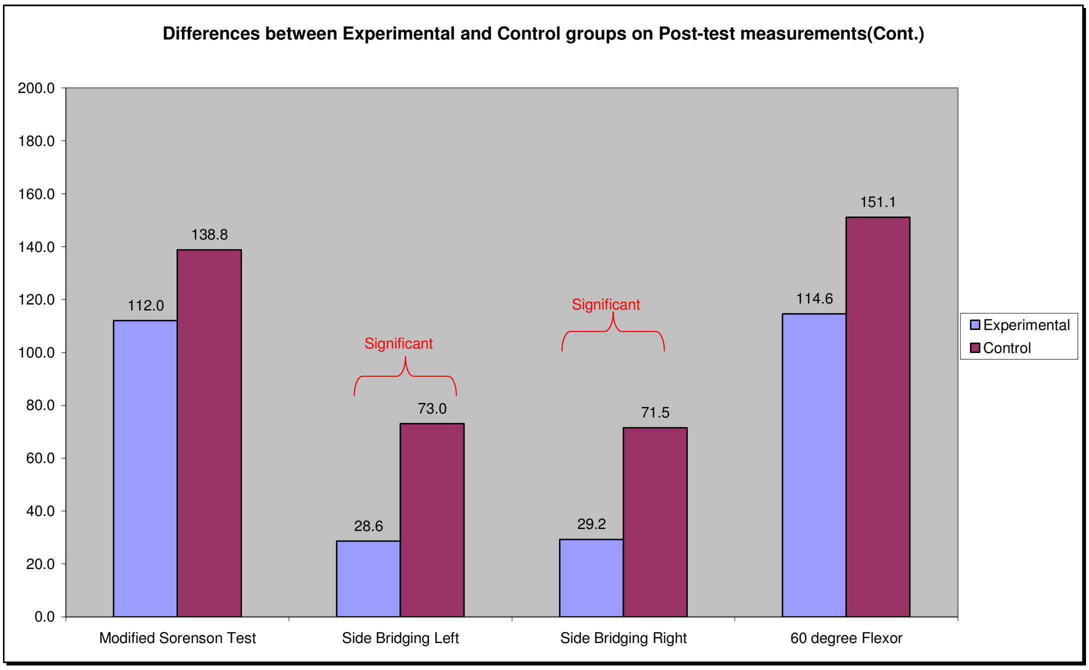


Figure 4.7: Difference Between Experimental and Control Groups on Post-test Measurements (continued)

4.5.5 Results of the Analysis to Test Whether Statistically Significant Differences Existed Between the Pre-test and Post-test Measurements Within the Experimental Group

Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:

- VAS Pain Score: The pre-test measurement was significantly higher than the post-test measurement.
- Oswestry Disability Index: The pre-test measurement was significantly higher than the post-test measurement.
- Functional Rating Index: The pre-test measurement was significantly higher than the post-test measurement.
- FABQ Scale 2: The pre-test measurement was significantly higher than the post-test measurement.
- FABQ Total: The pre-test measurement was significantly higher than the post-test measurement.
- Straight Leg Rise Hamstring Degree Left: The post-test measurement was significantly higher than the pre-test measurement.
- Straight Leg Rise Hamstring Degree Right: The post-test measurement was significantly higher than the pre-test measurement.
- Slump Test Right: The post-test measurement was significantly higher than the pre-test measurement.
- Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.
- Side Bridging Left: The post-test measurement was significantly higher than the pre-test measurement in the experimental group.
- Side Bridging Right: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.
- 60 Degree Flexor: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.

No statistically significant differences at the 5% level of significance were found between any of the other pre-test and post-test measurements within the experimental group. Results are summarised in figures 4.8 to 4.10 that follow.

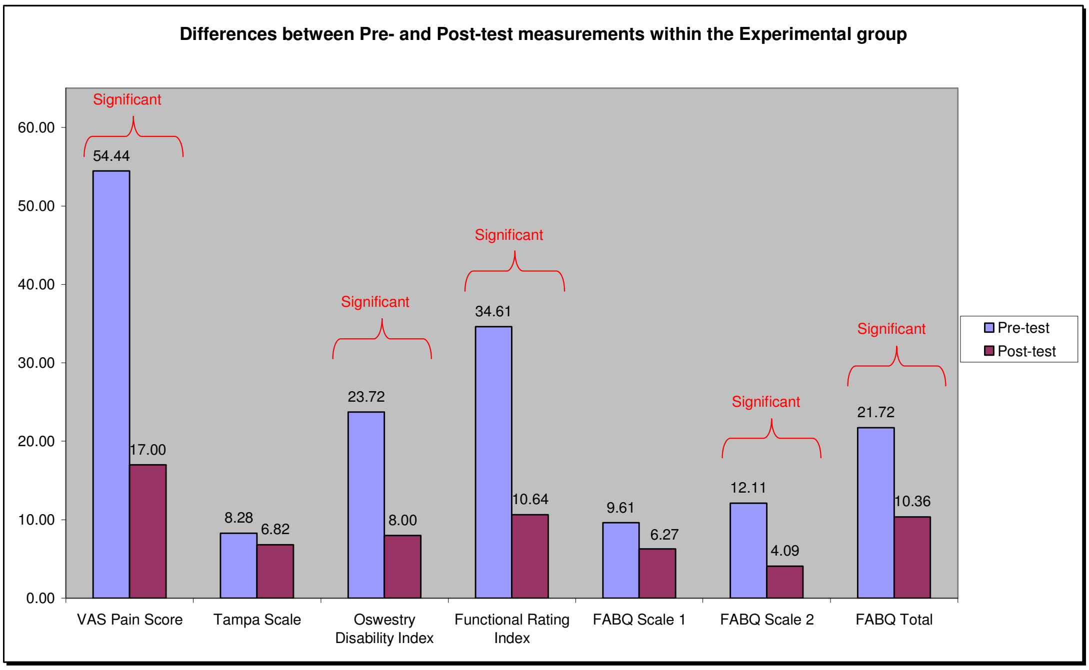


Figure 4.8: Difference Between Pre-test and Post-test Measurements within the Experimental Group

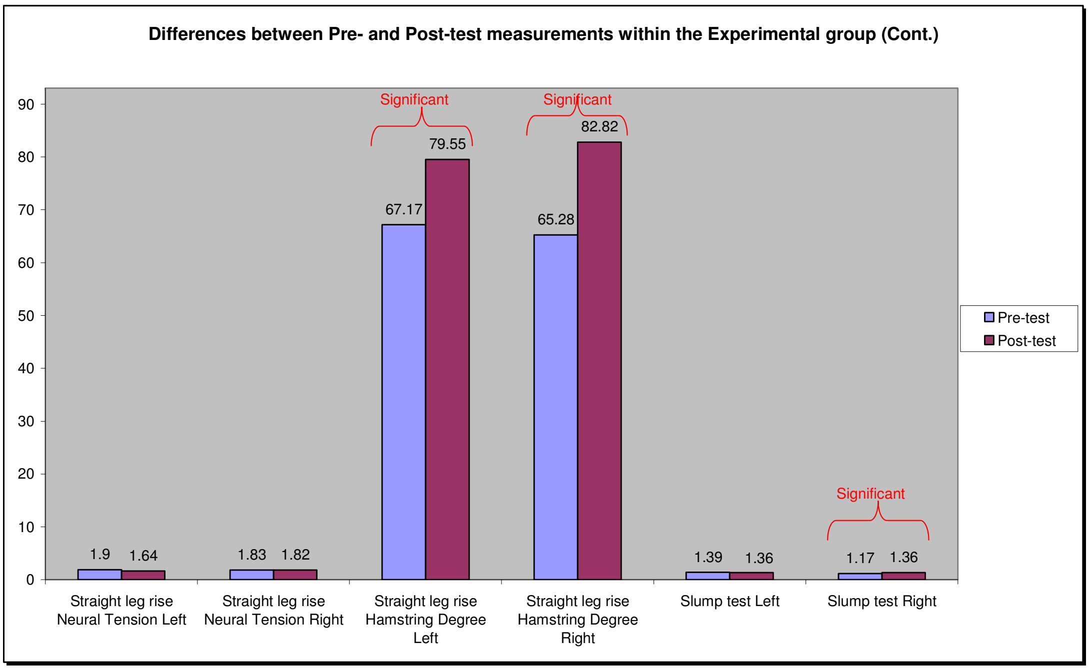


Figure 4.9: Difference Between Pre-test and Post-test Measurements within the Experimental Group (continued)

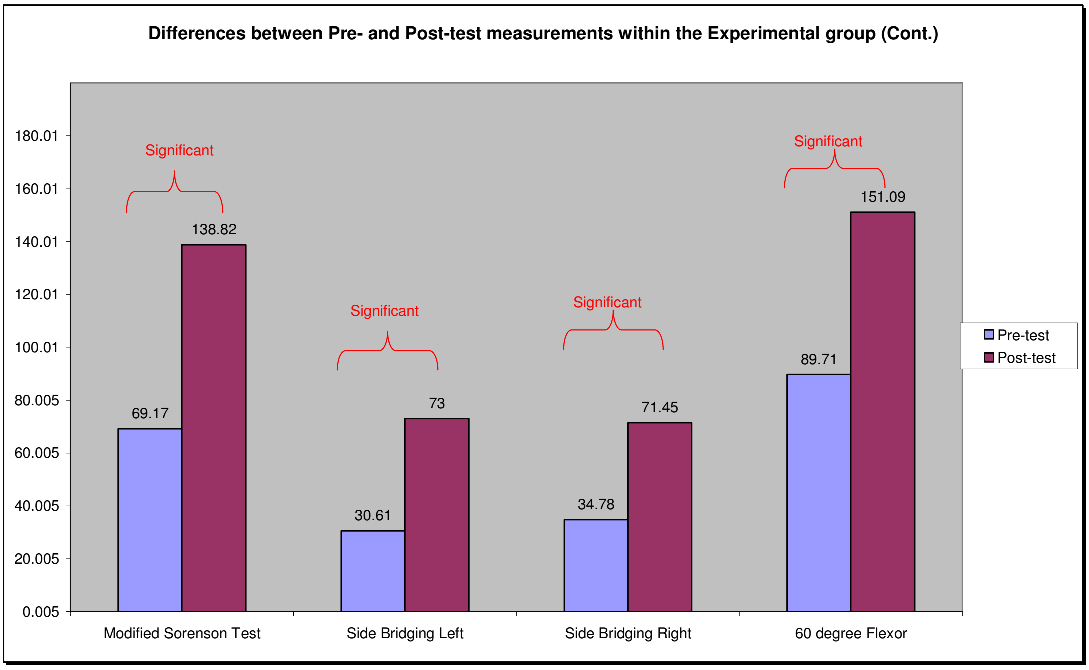


Figure 4.10: Difference Between Pre-test and Post-test Measurements within the Experimental Group (continued)

4.5.6 Results of the Analysis to Test Whether Statistically Significant Differences Existed Between the Pre-test and Post-test Measurements Within the Control Group

Statistically significant differences were found at the 5% level of significance between the following pre- and post-test variables within the control group:

- VAS Pain Score: The pre-test measurement was significantly higher than the post-test measurement.
- Oswestry Disability Index: The pre-test measurement was significantly higher than the post-test measurement.
- Functional Rating Index: The pre-test measurement was significantly higher than the post-test measurement.
- FABQ Scale 1: The pre-test measurement was significantly higher than the post-test measurement.
- FABQ Scale 2: The pre-test measurement was significantly higher than the post-test measurement.

- FABQ Total: The pre-test measurement was significantly higher than the post-test measurement.
- Straight Leg Rise Hamstring Degree Right: The post-test measurement was significantly higher than the pre-test measurement.
- Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the control group.

No statistically significant differences at the 5% level of significance were found between any of the other pre-test and post-test measurements within the control group. Results are summarised in figures 4.11 to 4.13 that follow.

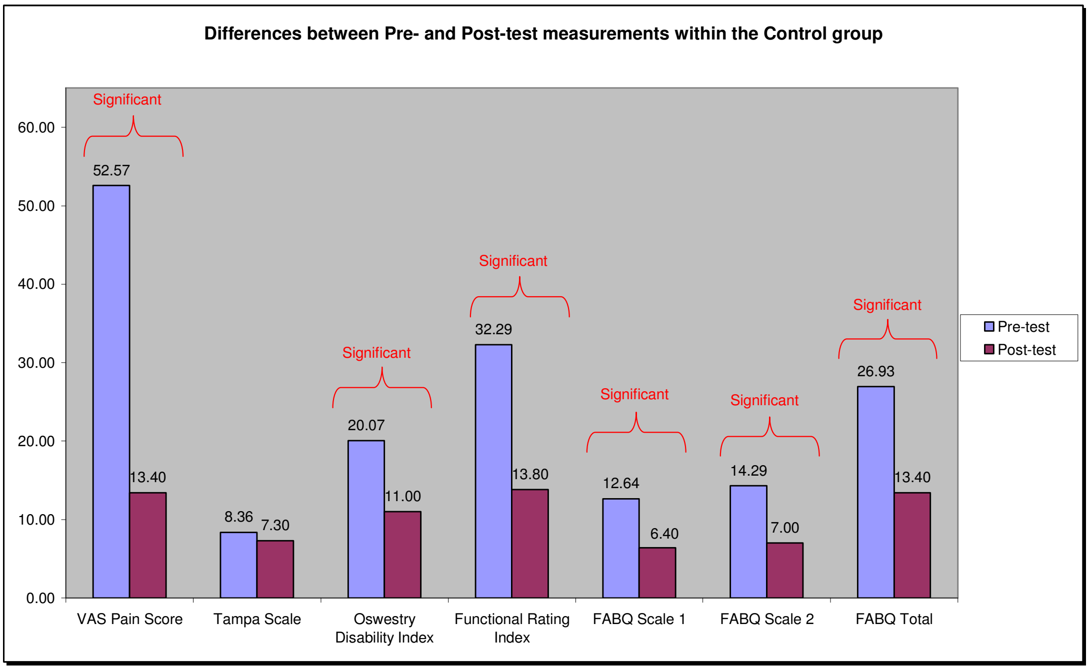


Figure 4.11: Difference Between Pre-test and Post-test Measurements within the Control group

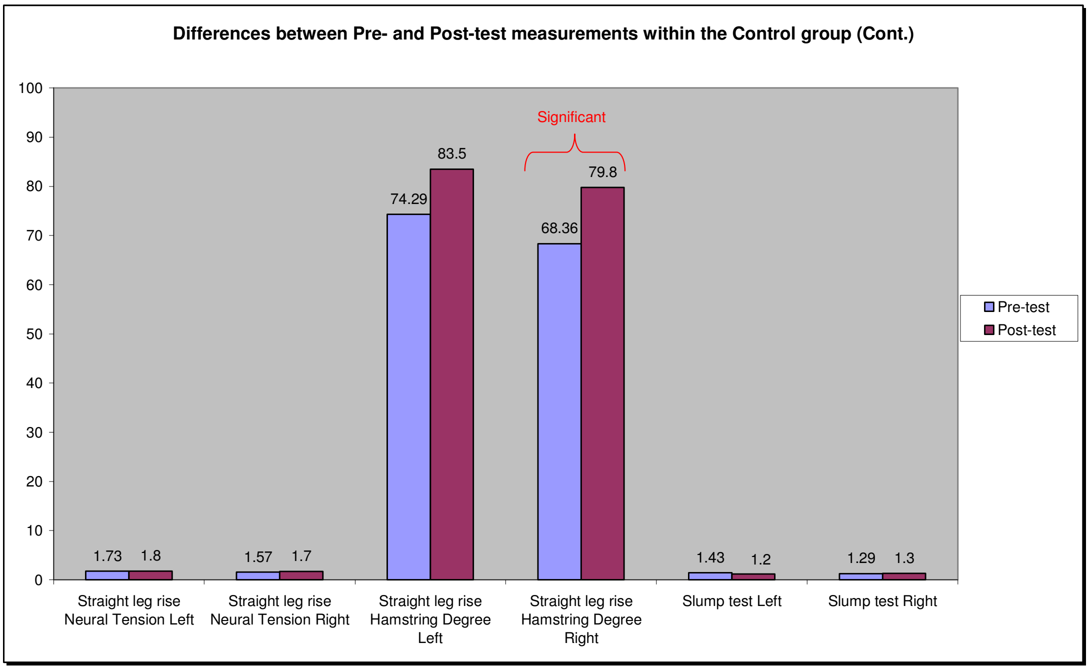


Figure 4.12: Difference Between Pre-test and Post-test Measurements within the Control Group (continued)

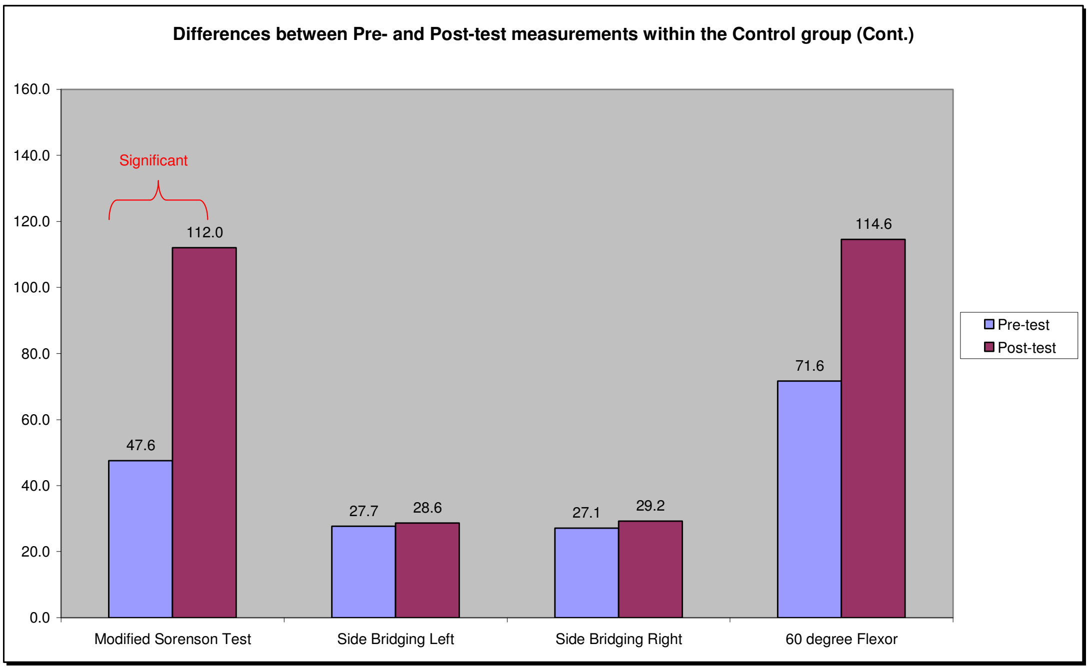


Figure 4.13: Difference Between Pre-test and Post-test Measurements within the Control Group (continued)

4.6 Case Studies

The present study utilised a 12 week, twice a week training (24 sessions) and back school regime. The ideal scenario would be a continual 24 sessions without missing a single session. However, due to the nature of the patients being full working capacity adults, this situation was not possible. Not one patient was able to complete a continual 24 sessions. Reasons include disease like colds and flu, working and family responsibility. However, most patients completed the programme within one or two weeks after the protocol was supposed to end. Some took much longer, as much as a month extra, to complete the programme.

The case studies will focus on two patients: one who completed the programme very close to 12 weeks and another who completed the programme in 16 weeks. Results on which will be focused, include important variables identified in the present study, such as pain (measured by the VAS pain scale), disability (measured by the Oswestry Disability Index and Functional Rating Index) and back extensor endurance (measured by the modified Sorensen test).

4.6.1 Patient A

Patient A is a 20-year-old female with a height of 1.73 m and a weight of 110 kg. Her history includes a diagnosis of mechanical back pain by a general practitioner. This has lasted for a year to date. She was advised to take part in an exercise programme for her low back pain. She reports working for 12 hours per day (student at university and part-time work for extra income). She reports high influence of back pain on her daily activities but also reports a need to have to continue with daily activities regardless of back pain. She was randomly allocated to the experimental group.

4.6.1.1 Pre-test Results

Her results at pre-test were as follows: The VAS score was measured at 54. Her Oswestry Disability Index score was 18 and her Functional Rating Index score was 20, while her back extension score was 0:58 minutes, with pain reported the reason for terminating the test. The mean VAS score in the experimental group at pre-test was 54.44; the Oswestry score was 23.72, the Functional Rating Index score was

34.61 and the back extension mean score was 69.17 seconds. The comparative scores were as follows:

Table 4.11: Mean Scores of Experimental group Compared to Patient A at Pre-test

Variable	Mean Score	Patient A Score
VAS Pain Score	54.44	54
Oswestry Disability Score	23.72	18
Functional Rating Score	34.61	20
Back Extension Score	1:10 minutes	0.58 minutes

The scores of Patient A were very close to those of the entire group. Her disability scores were slightly lower than the mean score. Patient A was able to complete the total programme in 12.5 weeks, which was the highest completion rate of all patients.

4.6.1.2 Post-test Results

Her VAS score improved to score 0 at post-test. She reported no pain at all at post-test. Her Oswestry Disability Index score and Functional Rating Index score also improved to 0. She reported that she experienced no disability at all at post-test. Her Sorensen back extension test score also improved, which measured at 3:00 minutes at post-test. She reported no problems during the test. The mean score of the group was measured at 17 for the VAS pain score, 8 for the Oswestry Disability Index, 10.64 for the Functional Rating Index and 2.3 minutes for the back extension test. The comparative scores are shown in the table below.

Table 4.12 : Mean Scores of Experimental Group Compared to Patient A at Post-test

Variable	Mean Score	Patient A Score
VAS Pain Score	17	0
Oswestry Disability Score	8	0
Functional Rating Score	10.64	0
Back Extension Score	2.3 minutes	3:00 minutes

As can be seen from the post-test scores, Patient A improved clinically in comparison to the mean score of the group. It can thus be argued that her scores improved due to her regular attendance of sessions and commitment to the programme.

Refer to Annexure D for patient report at end of the study.

4.6.2 Patient B

Patient B is a 22-year-old female with a height of 1.60 m and a weight of 59 kg. Her history includes a 4-year period of continuous pain. She had been participating in modern dancing activities for 17 years, which was identified as a possible causative factor in her back pain. She also has poor posture. She has been advised by her general practitioner to participate in a rehabilitation programme for her low back pain. She reports working for 16 hours per day (student at university and part-time work for extra income, as well as teaching dance classes). She reports high influence of back pain on her daily activities but also reports a need to have to continue with daily activities regardless of back pain. She was randomly allocated to the control group.

4.6.2.1 Pre-test Results

Her results at pre-test were as follows: The VAS score was measured at 59. Her Oswestry Disability Index score was 10 and her Functional Rating Index score was 23, while her back extension score was 0:32 minutes, with pain and weakness being reported as the reasons for terminating the test. The mean VAS score in the control group at pre-test was 52.57, the Oswestry score was 20.07, the Functional Rating Index score was 32.29 and the back extension mean score was 47.57 seconds. The comparative scores are shown in Table 4.13.

Table 4.13: Mean Scores of Control Group Compared to Patient B at Pre-test

Variable	Mean Score	Patient B Score
VAS Pain Score	52.57	59
Oswestry Disability Score	20.07	10
Functional Rating Score	32.29	23
Back Extension Score	0:47 minutes	0:32 minutes

The scores of Patient B were very different to those of the control group mean score. Her disability score was much lower than that of the mean score. She reported that she was still able to function despite her long history of low back pain. Patient B was able to complete the total programme in 16 weeks, which was the worst completion rate of all patients.

4.6.2.2 Post-test Results

Her VAS score improved to score 11 at post-test. She reported minimal pain and discomfort at post-test. Her Oswestry Disability Index score was measured at 2 and her Functional Rating Index score was measured at 5. She reported that she experienced no disability at all at post-test. Her Sorensen Back Extension test score did not show much improvement, being measured at 0:37 minutes at post-test. She reported anticipation of pain as the reason for terminating the test. The mean score of the group was measured at 13.40 for the VAS pain score, 11.00 for the Oswestry Disability Index, 13.80 for the Functional Rating Index and 1.9 minutes for the Back Extension test. The comparative scores are shown in Table 4.14 below.

Table 4.14 : Mean Scores of Control Group Compared to Patient B at Post-test

Variable	Mean Score	Patient B Score
VAS Pain Score	13.40	11
Oswestry Disability Score	11	2
Functional Rating Score	13.80	5
Back Extension Score	1.9 minutes	0:37 minutes

As can be seen from the post-test scores, Patient B improved clinically in comparison to the mean scores of the group. Pain levels improved slightly, but there were better improvements in the disability scores. Her back extension score was much weaker than the mean score of the group and only slightly better than her pre-test score.

Her improvement from pre-test to post-test was clinically relevant. This can be explained by two possible reasons: Firstly, because her attendance was irregular, it could be argued that her body did not receive the exercise stimulus regularly enough, and the improvement was not as great as some of the other patients in the control group who attended regularly. Secondly, because she has a much longer history of low back pain, her pain became very chronic. The effects of chronic pain had a longer time to develop in her than in some other patients. The effects of chronic pain had a longer time to develop in her than in some other patients.

Refer to Annexure D for patient report at end of the study.

Table 4.15: Comparison of Post-Test scores for Patient A and Patient B

Variable	Patient A Score	Patient B Score
VAS Pain Score	0	11
Oswestry Disability Score	0	2
Functional Rating Score	0	5
Back Extension Score	3:00 minutes	0:37 minutes

As shown in the Table 4.15 above, both patients' scores improved clinically. Only Patient B's back extension test score was poor, but the rest of the scores showed clinical improvement. From this table, it is clear that the exercise score of the regular attending patient (Patient A) was clinically better than that of the irregular attendant (Patient B). This provides evidence of the importance of regular attendance of training sessions concerning low back pain. Exercise stimulus needs to be provided regularly to enable the body to adapt to the training stimulus and to thus improve (Ahtiainen & Häkkinen, 2009; Hawley, 2009). Exercise cannot be completed irregularly and expected to have improved results in the physical testing.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The purpose of this study was to determine if an aggressive-progressive training programme would be more effective than more traditional conservative training programmes on subjects with chronic low back pain. Test variables included self-reported pain, kinesiphobia, disability, fear avoidance behaviour, rate of perceived exertion, time spent working and driving, neuropathic pain and several physical variables, which included low back extension endurance, lateral trunk muscle endurance, abdominal flexor endurance and demographic data such as age, height, weight and body mass index (BMI).

The subjects were randomised into a conservative exercising group and an aggressive-progressive exercise group. The conservative exercise group was labelled as the control group and the experimental [aggressive-progressive] group was labelled as the experimental group. Both groups trained twice per week under supervision for 12 weeks. After the 12 week intervention period all of the data was collected again and compared with the pre-test data.

5.2 Summary of Results

Main findings will be summarised in the following section.

- A statistically significant difference was found at the 5% level of significance between the experimental and control group for pre-test transport/driving time. The transport/driving time for the experimental group was significantly higher than that of the control group. No statistically significant differences were found between the pre-test of the experimental and control group for any of the other measurements. It can thus be concluded that, as far as the rest of the pre-test measurements are concerned, the two groups were very similar.

- Statistically significant differences at the 5% level of significance were found between the post-test measurements of the experimental and control group of the following:
    - Straight Leg Rise Hamstring Degree Right: The post-test value of the experimental group was significantly higher than that of the control group.
    - Side Bridging Left: The post-test value of the experimental group was significantly higher than that of the control group.
    - Side Bridging Right: The post-test value of the experimental group was significantly higher than that of the control group.

- No statistically significant difference was found between any of the other post-test measurements between the experimental and control group. It can therefore be concluded that, as far as the post-test measurements are concerned, the two groups were very similar with respect to the latter variables.

- Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:
    - VAS pain score: The pre-test measurement was significantly higher than the post-test measurement.
    - Oswestry Disability Index: The pre-test measurement was significantly higher than the post-test measurement.
    - Functional Rating Index: The pre-test measurement was significantly higher than the post-test measurement.
    - FABQ Scale 2: The pre-test measurement was significantly higher than the post-test measurement.
    - FABQ total: The pre-test measurement was significantly higher than the post-test measurement.
    - Straight Leg Rise Hamstring Degree Left: The post-test measurement was significantly higher than the pre-test measurement.
    - Straight Leg Rise Hamstring Degree Right: The post-test measurement

was significantly higher than the pre-test measurement.

- Slump Test Right: The post-test measurement was significantly higher than the pre-test measurement.
- Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.
- Side Bridging Left: The post-test measurement was significantly higher than the pre-test measurement in the experimental group.
- Side Bridging Right: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.
- 60 Degree Flexor: The pre-test measurement was significantly lower than the post-test measurement in the experimental group.

- No statistically significant differences at the 5% level of significance were found between any of the other pre-test and post-test measurements within the experimental group.

- Statistically significant differences were found at the 5% level of significance between the following pre-test and post-test variables within the experimental group:
  - VAS pain score: The pre-test measurement was significantly higher than the post-test measurement.
  - Oswestry Disability Index: The pre-test measurement was significantly higher than the post-test measurement.
  - Functional Rating Index: The pre-test measurement was significantly higher than the post-test measurement.
  - FABQ Scale 1: The pre-test measurement was significantly higher than the post-test measurement.
  - FABQ Scale 2: The pre-test measurement was significantly higher than the post-test measurement.
  - FABQ total: The pre-test measurement was significantly higher than the post-test measurement.
  - Straight Leg Rise Hamstring Degree Right: The post-test measurement was significantly higher than the pre-test measurement.

  - Modified Sorenson Test: The pre-test measurement was significantly lower than the post-test measurement in the control group.

- No statistically significant differences at the 5% level of significance were found between any of the other pre-test and post-test measurements within the control group.

5.3 Conclusion

Chronic low back pain does have a high prevalence rate with up to 84% reported in developed countries (Walker, 2000; Simmonds & Dreisinger, 2003). It constitutes a very high economic and personal cost from both medical usage, and loss of work time and production (Rizzo *et al.,* 1998; Childs *et al.,* 2004; Luo *et al.,* 2004; Louw *et al.,* 2007). This may lead to disability, which may increase the burden of low back pain if it occurs at an early age (Punnett *et al.,* 2005). Focus has to be to return those with chronic low back pain to work as soon as possible.

The low back has been recognised as a structure with intricate functions to maintain stability, which is crucial for safe and effective movement (Panjabi, 1992; Granata & England, 2006). The passive stabilising structure (bone, ligaments and discs) is the first part of this low back structure, and it has to absorb pressure without being able to change its' composition. The neural system forms the second component of the low back structure, and has to be able to make adaptations to changing stresses. The muscle system is the third part of the low back structure, and this part forms the dynamic stabilising structure of the spine (Panjabi, 1992; Granata & England, 2006).

The muscular system consists of the global muscle system consisting of large, torque-producing muscles that act on the trunk and spine without being directly attached to it (Bergmark, 1989a). It includes the rectus abdominis, external oblique and the thoracic part of the lumbar iliocostalis. The local muscle system consists of muscles that directly attach to the lumbar vertebrae. It is responsible for providing segmental stability and directly controls the lumbar segments. By definition the multifidus, transversus abdominis and the posterior fibres of the internal oblique all form part of this local muscle system (Bergmark, 1989a). Both these systems work together to achieve total stability of the spine. It is these systems on which are focused when performing exercises for low back pain. Stability of the spine is further achieved by performing spinal stabilisation, which ensures that the spine maintains its position of neutral spine (Lam *et al.,* 1989).

Exercise therapy has been reported to be successful in the treatment of chronic low back pain (Spitzer *et al.,* 1987; Koes *et al.,* 1991; Nordin & Campello, 1999; Van der Velde & Mierau, 2000; Albright, 2001; Friedrich *et al.,* 2005; Hayden *et al.,* 2005; Krismer & Van Tulder, 2007). Aerobic exercise alone has shown positive results, but no significant improvement compared to other types of exercise. Any exercise that increases functionality and gives the subject a feeling of control is effective in treating chronic low back pain (Petersen *et al.,* 2002). Stabilisation exercises have been shown to have the most significant results (Van Vliet & Heneghan, 2006; Tsao & Hodges, 2008). Exercise programmes that contain functional exercises, which involve both the local and global musculature combined with cognitive intervention have been shown to generate even better results (Bergmark, 1989a).

The results from the present study indicate that an aggressive-progressive exercise programme may be more effective than more conservative exercises in the treatment of chronic low back pain. Both types of programmes have shown to be very effective in the treatment of chronic low back pain in the present study, as well as in the literature (Koes *et al.,* 1991; Nordin & Campello, 1999; Van der Velde & Mierau, 2000; Friedrich *et al.,* 2005). However, more aggressive types of training programmes are suggested in the literature for the treatment of chronic low back pain (Manniche *et al.,* 1991; Johannsen *et al.,* 1995; Oldervoll, 2001; Petersen *et al.,* 2002; Ostelo *et al.,* 2003) due to the need to improve overall functionality and decrease disuse that results from the consequence of pain. Pain itself is not regarded as the limiting factor in chronic low back pain cases (Staal *et al.,* 2003; Staal *et al.,* 2005).

Because of the importance of pain being recognised as a disease in itself (Meyer, 2007) more focus needs to be placed on pain management, especially chronic pain and pain 'diseases' such as neuropathic pain. Results from the present study confirm this view. All of the subjects who volunteered for the study, even those who fell out, did so because they experienced low back pain. None wanted to participate because they felt that their back muscles were weak or that they were suffering from fear avoidance behaviour. All of them wanted a potential cure for their low back pain. This shows a potential conflict in the expectations of subjects and the goal of research. Research recommends that the consequences of pain be addressed before pain itself is addressed, because pain is a very subjective experience. However, pain relief is the primary goal for subjects, as many of them feel that they can resume normal activities once their pain has subsided. But this illustrates unrealistic goals from subjects, as they expect their pain to disappear completely. Unfortunately it is reported that pain has a high reoccurrence rate (Staal *et al.,* 2005) and subjects often have unrealistic beliefs about pain and injury (Waddell *et al.,* 1993; Picavet *et al.,* 2002). That is why it is important to merge the goals of treatment with those of the subjects. If not, the treatment will be ineffective or the subjects will lose interest. This has to be explained to the subject (Meyer, 2007) in detail right from the start.

The experience of chronic pain has certain physical and psychological consequences. These include disability, fear avoidance behaviour, physical deconditioning and weakening of muscles, and possible permanent absence from work. All of these factors have to be addressed in order for the subject to have a favourable outcome as these factors pose a greater problem than pain alone. This can best be achieved by a multidisciplinary/interdisciplinary team consisting of various medical professionals who all work together to achieve maximum levels of success with a subject.

The present study found that a well-structured progressive-aggressive programme could be as effective as conservative exercise programmes that have been used in the past. In both groups pain levels, levels of disability and muscle endurance strength all improved. In most cases the progressive-aggressive group showed better improvements than the conservative group, although not significant. The progressive-aggressive group addressed the functional capacity component, which the conservative group did not.

The two case studies also showed significant improvements compared to the mean scores of the rest of the group. Both subjects improved more than or just as much as the group overall. In comparison they also showed good improvement, with subject A performing better in most of the post-tests. Subject A was also the more regular attendee and finished the course only slightly overdue, while it took subject B a month longer to complete the course. This could be a reason why subject A performed better in the post-test.

These case studies provided evidence of the perception of the two subjects that none of the other tests would have been able to provide. It provided evidence of the importance for the subjects to reduce their back pain and to increase their functional ability. Although disability levels were low in the entire population group subjects were still affected by their back pain in that they had lost interest, productivity and self-satisfaction in not only recreational activities but also in work-related activities. This supports the idea of the focus on pain reduction being a secondary goal and the focus on alleviating the consequence of pain being a primary goal (Staal *et al.,* 2005).

5.4 Recommendations

From the present study the following recommendations can be made:

- Aggressive progressive exercise programmes for chronic low back pain can be very effective. The exercise programme has to contain both stabilising exercises and exercises for larger muscle groups to restore functional capacity.
- Exercise programmes should contain exercises for both the global and local muscle groups. Muscles involved in stabilisation, extension, flexion, lateral flexion and rotation should all receive attention. Research has advocated the importance of the extensor muscle groups and they should receive priority treatment. The other muscle groups should not be neglected though and have to be properly exercised as well.
- Due to the importance of restoring functional capacity other exercises need to be included in the exercise programme in order to train the larger movement muscle groups. Muscles such as those of the legs, chest and shoulders need to be included to strengthen them to restore the functional capacity tasks for which they are responsible.

- Exercise programmes should also contain some form of aerobic exercise. Due to the progression of chronic low back pain subjects tend to undergo deconditioning as a result of less participation in activities. Aerobic exercises will re-establish aerobic capacity and enable subjects to return to their normal activities without exertion inhibiting them. The aerobic exercises will also help to maintain their health status and prevent diseases such as diabetes from becoming problematic because of decreased levels of activity.

- Stretching exercises need to be done along with strengthening exercises. The stretching exercises are not done to necessarily improve the flexibility of the low back muscles, but to rather maintain the flexibility of the hips and legs. The gluteus muscle group and the quadriceps muscle group, as well as the hamstring muscle group need specific stretching exercises to maintain their mobility which is in danger as a result of restricted movement because of pain.

- It has been reported that subjects need up to approximately 20 supervised training sessions to achieve a significant amount of success (Sanders & Brena, 1993). The present study used 24 sessions. This achieved a fair amount of success. However, many subjects complained about the length of the programme and remarked that they would not have finished the programme if they had to pay for it. Many subjects felt improvement after 6-10 sessions. It is thus recommended that at least 10 sessions be done and then it could be decided to continue or to discharge the subject with home-based exercises. This is particularly important concerning those in full working capacity.

- Subjects should receive both supervised exercise training and unsupervised home training programmes. The unsupervised home training programmes should not be too long in duration or too complicated, but should still be performed at least once daily. Compliance is always a problem with unsupervised home exercise programmes. However, the subjects have to be informed of the importance of the home exercise programme from the start. He or she has to be willing to accept responsibility for his or her own treatment outcomes. The present study did not use any form of extra home training in order to control the specific exercise activity of subjects, thereby increasing the internal validity of the study. The use of home exercises has been reported inthe literature (Arokoski *et al.,* 2004; Sherman *et al.,* 2005) and it is advised to use them in conjunction with thenormal regime of training for low back pain.

- Subjects have to be taught the stabilisation method or a variant thereof. This will place emphasis on the stabilisation muscles and prevent the use of the mobilisation muscles for the specific stabilisation exercises. It will further retrain these muscles and ensure the grooving of proper neuromuscular activation patterns.

5.5 Future Research

- More research has to be conducted on pain management, especially where exercise treatment modalities are concerned. Exercise appears to be a very effective treatment modality for low back pain, but it is not perfect. Combining exercise treatment with other modalities, especially cognitive behavioural treatment, seems to be the most effective. But pain needs special attention, especially if components such as central sensitisation and diseases such as fibromyalgia are involved. Exercise, combined with pharmaceutical intervention, can be more effective than executed separately. Especially combining medicine and exercise for low back pain with a fibromyalgic component needs further research. The type, intensity, frequency and duration of the involved exercise need to be better researched.

- Research also needs to focus on neuropathic pain combined with low back pain. None of the subjects in the present study showed signs of neuropathic pain, although three of them scored a 3 on the DN4 questionnaire. This would suggest that neuropathic pain did not play a role in presenting pain in the present study. However, neuropathic pain is identified as a major component in many people suffering from chronic low back pain. Research thus needs to focus on the use of exercise in treating neuropathic pain. Especially resistance exercise needs more emphasis.

- More intensive research needs to be done on the correct intensity, frequency and duration for all sub-groups of low back pain that will benefit from exercise intervention therapies. Establishing intensities for remedial exercise programmes can be difficult and specific guidelines for intensity are still needed. Frequency and duration should also be researched more regarding their ideal dosage. The reason is that the intensity, frequency and duration differ from study to study. The type of exercise also needs to be researched in order to establish which specific exercises would be effective and which could be eliminated. The present study used specific exercises selected from the literature. These exercises need to be used in future studies in the same intensity, frequency and duration as in the present study.

- Especially exercise intensity needs to be researched, as very few guidelines exist in the literate to guide intensity in exercise for chronic low back pain. The present study attempted to use the Borg rate of perceived exertion scale (RPE) to determine the intensity of the exercises in the experimental group. Future research needs to establish whether the RPE scale is an effective method for guiding low back pain rehabilitation exercises and whether it could be used to guide intensity as effectively as it guides high performance exercise intensity. The present study only used the RPE scale for the experimental group and not for the control group. It was also used only at the end. The RPE scale has great potential to measure exercise intensity but specific levels of safe intensities need to be established as guidelines for those with chronic low back pain.

- Future research also has to look at some of the more common exercises used in chronic low back pain research and practice. Exercises such as the alternative superman and all of its versions have to be compared more in-depth. Attempts should be made to establish what exercise is sensible for certain phases of the rehabilitation programme. Past research has used EMG studies in an attempt to determine the effectiveness of the frequently used remedial studies. Future research needs to standardise the use of these exercises in order to provide guidelines for their utilisation.

- Future research needs to establish whether the Ito test is an effective substitute for the Sorensen back extension endurance test for those with chronic low back pain. Some subjects find the Sorensen test intimidating. Therefore, a test that could theoretically place less strain on the low back could be very effective in testing those with chronic low back pain safely but still effectively. The test needs to be validated by using healthy subject data to establish norms, and to compare with those suffering from chronic low back pain and other forms of low back pain.

- When performing any type of extension endurance testing, research has to attempt to establish whether test termination is due to pain or to true muscular endurance. Pain is difficult to measure because of its subjective nature but establishing a difference between pain and muscular weakness in endurance testing will give a more accurate picture of those who are at a greater risk of developing chronic low back pain due to weakened back extensor muscles.

- More research needs to be done on those subjects in full working capacity. Results from the present study indicate that this specific population might not be as disabled as previously thought, although they have been suffering from chronic low back pain for a substantial amount of time. Incorporating remedial exercises into their daily routine is a barrier to participation. Research needs to focus on how to incorporate meaningful exercises into the daily routines of those working full-time as not to create the impression that the exercises are impeding on their daily routines. This type of future research thus needs to focus on compliance.

- Larger sample groups need to be used in similar studies. Although the logistic problems with this kind of study have been documented, larger sample groups will provide more statistically significant results. The results from the present study were clinically significant but larger groups will provide statistical and clinical significance. Especially using larger sample groups to rehabilitate the subjects through the whole rehabilitation process will give a more statistically significant meaning to the results.

- It also needs to be established whether those in full working capacity will benefit from more or from less back school time. Subjects from the present study were all working full-time and attended the programme sessions at the end of a long working day. All were tired and their attention span was limited. Research needs to establish what amount of back school counselling will be effective, yet still transfer information and retain subject attention. The duration should not be so lengthy as to induce boredom in subjects.