The Effectiveness Of Gluteus Medius And Iliotibial Band Stretching, Versus Strengthening, In The Rehabilitation Of Iliotibial Band Syndrome In Long Distance Runners.

By:

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A Dissertation submitted in partial compliance with the requirements for a Master's Degree in Technology: Chiropractic, at the Durban Institute of Technology.

I, AK. Gangat, do hereby declare this dissertation to be a true representation of my own work.

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Approved for final examination by:

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Dr. A. Docrat. (supervisor) Date

Dedication

I would like to dedicate this work to the three ladies who make my life very special.
To my wife, my mother, and my sister.

Acknowledgements

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Abstract

The purpose of this pre-post crossover clinical trial was to investigate the relative effectiveness of the combination of stretching followed by strengthening, versus the combination of strengthening followed by stretching, of the gluteus medius and iliotibial band (ITB), in the rehabilitation of chronic Iliotibial Band Syndrome (ITBS) in long distance runners. The results were based upon subjective and objective clinical findings, as well as effect on running performance.

This study included a sample of 30 participants with chronic ITBS. They were divided randomly and equally into two groups, “C” and “G”. For the first half of the study (the first period, which lasted 3 weeks), Group “C” received treatment in the form of a stretching exercise daily, while Group “G” received treatment in the form of a strengthening exercise daily. For the second half of the study (the second period, which also lasted 3 weeks), the groups crossed over, exchanging treatment techniques.

Subjective measurements were obtained using the Numerical Pain Rating Scale – 101 and the Short-form McGill Pain Questionnaire. Objective measurements were obtained using the Gluteus Medius Strength Test, Modified Ober’s Test (with the use of a digital inclinometer to measure hip adduction angle), Noble’s Compression Test, and Algometer readings for point tenderness at the distal end of the ITB. The effect on running performance was determined with an ITB questionnaire and the participants’ ability to perform the stretching and strengthening exercises was rated in a Daily Exercise Diary. All measurements were taken at the beginning of each weekly visit.

Numerical outcomes for inter-group and intra-group analysis were done with SPSS using the repeated measures ANOVA (Analysis of Variance). Analysis of

categorical outcomes for inter-group and intra-group data was done in STATA using the GEE (Generalised Estimating Equation) models. The level of significance was set at $\alpha=0.05$ with a 95% confidence interval.

The results of this study demonstrated that for the majority of the outcomes there was no statistically significant difference between the effectiveness of the stretching and strengthening exercises, or the order in which the exercises were done (inter-group analysis). The period effect (duration of the intervention) was significant for most outcomes, meaning that there was a statistically significant change in the outcomes from both periods, regardless of the order of the exercises (intra-group analysis). Ultimately, having done both exercises was significantly better than having done one exercise, regardless of which exercise was done first.

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Definition of Terms

Treatment Effect:

"Treatment Effect" in this study, refers to the effect of Stretching compared to the effect of Strengthening (stretching and strengthening being the two treatments involved in this study).

Period Effect:

"Period Effect" in crossover studies has two levels: Period 1 and Period 2. In this study, Period 1 is the first three weekly Follow-Ups, and Period 2 is the second three weekly Follow-Ups in this study. The Period Effect is therefore the effect from Period 1 for Group "G" compared to the effect from Period 2 for Group "C", as well as the effect from Period 1 for Group "C" compared to the effect from Period 2 for Group "G" (see table below).

Group	Period 1	Period 2
"G"	Strengthening	Stretching
"C"	Stretching	Strengthening

"Period Effect"

Group Effect:

"Group Effect" in this study, refers to the effect of having been in Group "G" (having received strengthening before stretching), compared to the effect of having been in Group "C" (having received stretching before strengthening).

Chapter One

<u>*Introduction*</u>

1.1. The problem and its Setting:

Iliotibial Band Syndrome (ITBS) is an overuse injury induced by friction of the iliotibial band (ITB) over the lateral femoral epicondyle, with secondary inflammation (Lindenberg *et al,* 1985). The condition is the most common cause of lateral knee pain in runners, and has an incidence of about 12% of all running-related injuries (Noble *et al,* 1980).

The most common symptom of the ailment is sharp or burning pain on the lateral aspect of the knee (Fredericson *et al,* 2000). Runners often note that they start out running pain free but develop the symptoms after a reproducible time or distance. In severe cases, pain may even persist when walking, especially with ascending and descending a flight of stairs (Fredericson *et al,* 2000; Reid, 1992:424).

A number of aetiological factors have been related to ITBS, a variety of which occur in presenting patients. Lindenberg *et al* (1985), and Reid (1992:424-429) discuss the following aetiological factors: Training errors, which include increasing mileage too quickly, inadequate warm-ups, and road camber; Biomechanical factors, which include genu varum, foot hypersupination, foot overpronation, or cavus foot, and leg length discrepancies. Footwear with poor shock absorption has also been implicated (Baker, 1995) and most recently, hip abductor weakness (Fredericson *et al,* 2000).

These aetiological factors were found to ultimately result in excessive tautness of the ITB, and hence, the friction syndrome (Lindenberg *et al,* 1985; Noble *et al,* 1980; Reid, 1992:424-429).

Due to this variety of aetiologies, the treatment of ITBS has been multifactorial. Reid (1992:424-429) and Fredericson *et al,* (2000) outline the following treatments: The reduction of inflammation (using ice and anti-inflammatories); reduction of tautness and myofascial trigger points in the band (employing stretch techniques and trigger point therapies); Corrective actions (involving easy training and avoidance of cambered roads and downhill running); and the correction of biomechanical abnormalities with orthotics, are all employed. Surgery is sometimes opted for in especially stubborn chronic cases, and involves snipping the posterior half of the band, where it rubs over the lateral femoral epicondyle (Martens *et al,* 1989).

Most research done on ITBS thus far has focused mainly on the effectiveness of various treatment techniques to the ITB itself and/or its associated tensor fascia lata (TFL) muscle, with varying results reported (Hall, 1997 and Baer, 1999). These include conservative therapies like rest, ice, and stretching of the tight band; myofascial trigger point therapies like dry needling; and ultimately, surgery.

Other studies have been aimed at identifying and correcting primary aetiological factors, such as biomechanical abnormalities (eg: genu varus, cavus foot type, leg length inequalities, sacroiliac joint fixations, and fibular head fixations) – also with varying results (Reid, 1992:425, and Lindenberg *et al*., 1985).

Some of the latest studies (Baker, 1995 and Fredericson *et al,* 2000) have identified an association between weak hip abductors (especially the gluteus medius) and ITBS. These studies suggest that gluteus medius weakness, and/or myofascitis of the gluteus medius is another contributing factor to ITBS in long distance runners. Gluteus medius strengthening in the treatment of ITBS has been a recent focus of investigation in the literature (Fredericson *et al,* 2000).

The literature reveals that the comparative effectiveness of this new approach to ITBS treatment based on gluteus medius strengthening, to any other form of conservative treatment, requires further investigation (Lindenberg *et al,* 1985; Baker, 1995; and Fredericson *et al,* 2000). Stretch therapy has traditionally been the basis of the conservative treatment for ITBS - i.e., to stretch the tight band and thereby reduce the friction syndrome – a proven effective component of conservative treatment for ITBS (Fredericson *et al,* 2002). Since it is already known that both techniques are indeed effective in the treatment of ITBS, it may therefore prove more valuable, instead of investigating their relative effectiveness, to rather investigate the effect of both techniques in different combination, i.e. the combination of stretching followed by strengthening, compared to the combination of strengthening followed by stretching, of the gluteus medius and the ITB, in the rehabilitation of chronic ITBS.

1.2. The Statement of the Problem:

The aim of this study was to determine the relative effectiveness of the combination of stretching followed by strengthening, compared to the combination of strengthening followed by stretching, of the gluteus medius and the ITB, in the rehabilitation of chronic ITBS in long distance runners.

The objective was to measure this difference, if any, in terms of subjective pain perception and objectively by orthopaedic testing, as well as functionally in terms of the effect on running performance.

Chapter Two

<u>Literature Review</u>

2.1. Introduction:

The purpose of this chapter is to highlight relevant literature regarding information on ITBS occurring specifically in long distance runners, and the management of this injury. The research is limited in showing the effectiveness of combining the newly investigated conservative therapy of gluteus medius strengthening, with other proven conservative therapies for ITBS, in the rehabilitation of chronic ITBS. This study will propose to address this issue, using stretching – one of the most fundamental of conservative approaches to ITBS treatment – in different combination with strengthening, i.e. the combination of stretching followed by strengthening, compared to the combination of strengthening followed by stretching, of the gluteus medius muscle and the ITB, in the rehabilitation of chronic ITBS in runners.

2.2. Definition:

Iliotibial Band Syndrome (ITBS) is an overuse injury induced by friction of the Iliotibial Band (ITB) over the lateral femoral epicondylar prominence, with secondary inflammation (Lindenberg *et al,* 1985).

2.3. Epidemiology:

In South Africa, ITBS is most frequently seen in runners and cyclists, while in other countries, the condition is also frequently seen in skaters, cross-country skiers, and weightlifters (Hall, 1997). ITBS accounts for $1/5^{th}$ to $1/3^{rd}$ of all knee injuries in the US and Canada (Noble *et al,* 1980). ITBS is the most common cause of lateral knee pain in runners, and it bears an incidence of 12% of all running related overuse injuries (Lindenberg *et al,* 1985; Noble *et al,* 1980). ITBS has therefore come to be historically considered as a running related injury (Baker, 1995). This is due to the repeated flexion and extension movements of the knee – as in long distance running – that causes inflammation due to friction.

2.4. Symptoms :

The most common symptom of the ailment is sharp or burning pain on the lateral aspect of the knee (Fredericson *et al,* 2000). Runners often note that they start out running pain free but develop the symptoms after a reproducible time or distance. Early on, symptoms subside shortly after a run, but return with the next run. If ITBS progresses, pain can persist even during walking, particularly when the patient ascends or descends stairs (Fredericson *et al* 2000; Reid, 1992:424).

The severity of ITBS is commonly categorised through Grades 1 to 5 as follows: (Reid, 1992:425)

I – Pain comes on after running, and does not restrict distance or speed.
II – Pain comes on during a run, but does not restrict distance or speed.
III – Pain comes on during a run, and restricts distance or speed.
IV – Pain is so severe that it prevents running.
V – Pain is continuous during activities of daily living.

All participants in this study were graded according to the above classification. In keeping with the fact that this was a rehabilitative study for runners with chronic ITBS, all participants accepted into the study were between Grades I and III only. This also helped to ensure homogeneity of the sample.

2.5. Anatomy:

2.5.1. The Iliotibial Band:

According to Travell and Simons (1992:219), the iliotibial band, or tract, is a condensation of the vertical fibres of the fascia lata, which originate over the lateral edge of the iliac crest, especially the iliac tubercle. These vertically descending fibres converge on the knee and mostly attach to the lateral tibial tubercle (Gerdy's tubercle). Some fibres blend anteriorly with the patellar retinaculum, some go deep to attach to the lateral femoral condyle, and some onto the tibial tuberosity. (see *Fig. 2.1*).

The ITB crosses the joints of the hip and the knee, and its effect on the knee therefore varies according to the position of the hip (Evans,1979). Reid (1992:424) mentions that the ITB receives muscular attachments from the tensor fascia lata, gluteus maximus, and gluteus medius muscles at its proximal aspect, and that the function of these muscles is threefold. Firstly, their attachment serves to tense the band during supporting actions, particularly when weight bearing on one leg. Secondly, the tension produced in the band by the contraction of these muscles prevents adduction of the lower extremity. And thirdly, the tensor fascia lata pulls the band anterior to the lateral femoral condyle during hip extension, while the gluteus maximus pulls the band posteriorly over the lateral femoral condyle.

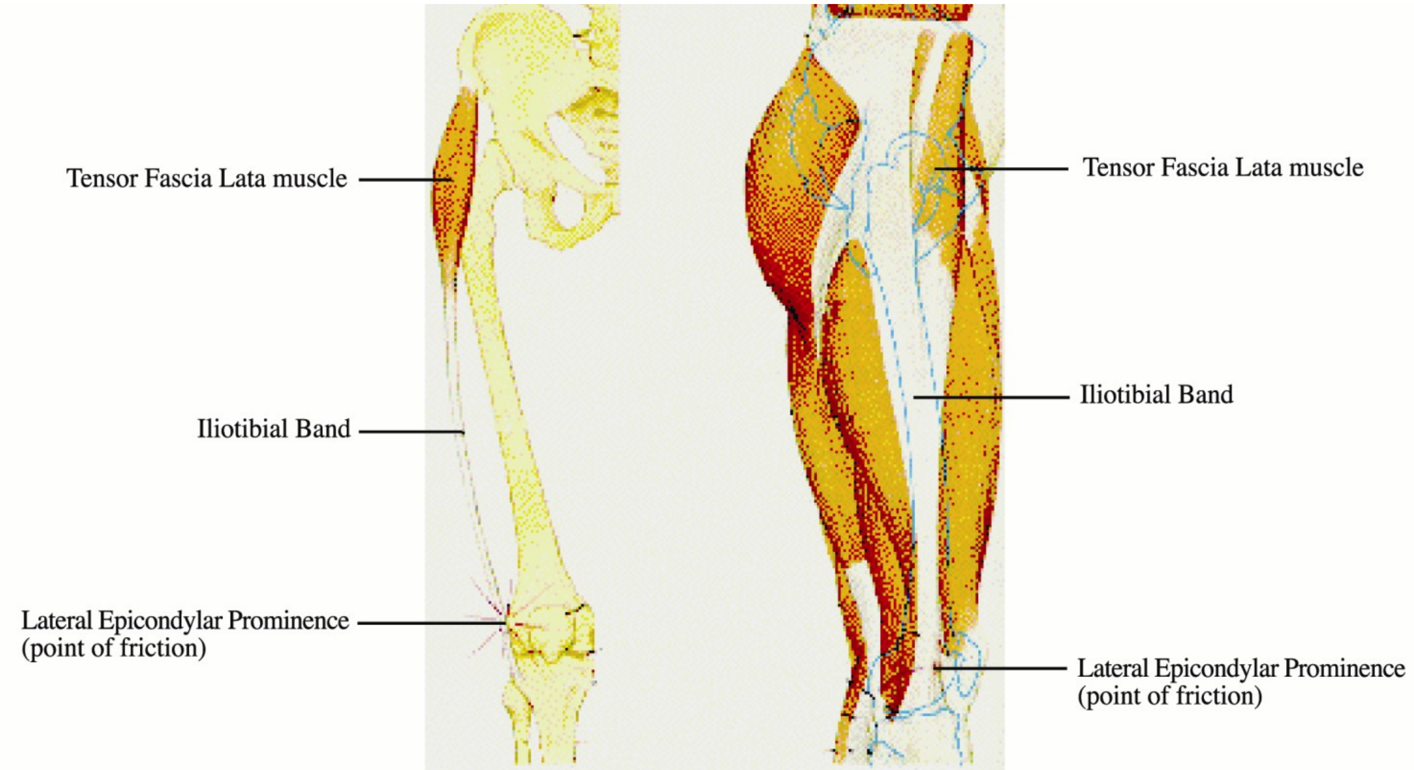


Figure 2.1 The Iliotibial Band

2.5.2. The Tensor Fascia Lata (TFL):

According to Travell and Simons (1992:218), the TFL has its origin at the anterior iliac crest and the anterior superior iliac spine. Its anteromedial tendinous fibres terminate in the lateral patellar retinaculum and in the deep fascia of the leg superficial to the patellar ligament. The posterolateral half of the muscle's tendon attaches below the knee onto the lateral tubercle of the tibia via the iliotibial tract, from which some fibres branch to the lateral femoral condyle and the linea aspera of the lower femur. The TFL is innervated by a branch of the superior gluteal nerve with derivations of L4, L5 and S1 spinal nerves.

In normal gait, the TFL functions to assist hip flexion during the swing phase and assists stabilisation of the pelvis during the stance phase. It acts to assist flexion, abduction and medial rotation of the thigh, and helps to stabilise the knee. The most anteromedial fibres are always involved in flexion and abduction of the thigh. The most posterolateral fibres always assist in medial rotation of the thigh and stabilisation of the knee (Travell and Simons, 1992:219-220).

2.5.3. The Gluteus Medius:

Travell and Simons (1992:152) state that the gluteus medius is a thick fan shaped muscle that lies deep to the gluteus maximus and superficial to the gluteus minimus on the outer surface of the ilium. It has its origin on the outer surface of the ilium along the iliac crest, between the anterior and posterior gluteal lines. Its fibers pass downward and laterally and are attached to the outer surface of the greater trochanter of the femur. The muscle is innervated by the inferior branch of the superior gluteal nerve, with derivations of L4, L5 and S1 spinal nerves.

Functionally, the gluteus medius is the most powerful abductor of the thigh, and is chiefly responsible for stabilising the pelvis during single limb weight bearing. During ambulation, the gluteus medius and other abductors prevent the pelvis from dropping excessively toward the unsupported side (Travell and Simons, 1992:152).

2.6. Biomechanics:

Reid (1992:1131-1137) explains that long distance runners place tremendous demands on their lower extremities, with 2-3 times the body weight being absorbed by the musculoskeletal system at every heel strike, which occurs between 500-600 times per kilometre. The running gait cycle has two phases: The stance phase, which consists of heel strike, midsupport and take-off; and the swing phase, which consists of follow-through, forward swing and foot descent. During the early stance phase the foot pronates, causing the tibia to internally rotate and the knee to be stressed into valgum. This in turn pulls the femur into adduction. This adduction of the femur is countered by the hip abductors to prevent the knee from moving too far medially. The hip abductors therefore contract strongly every time the runner's heel strikes the ground, and remain working throughout the running cycle to help stabilise the pelvis.

According to Schneider (1990), during the stance phase, the bodyweight is centred over the symphysis pubis, which creates a lever arm from the pubis to the hip. This leverage creates a demand on the ipsilateral abductors to contract strongly to prevent the pelvis and the whole torso from falling to the contralateral side. With the TFL acting on the ITB to contribute to controlled hip abduction, in combination with the main action of the gluteus medius and other hip abductors, pelvic stability is achieved and maintained through the running gait cycle.

Fredericson *et al,* (2000) explain that the gluteus medius and tensor fascia lata are both hip abductors, but the gluteus medius (mainly its posterior fibres) also externally rotates the hip, whereas the tensor fascia lata also internally rotates the hip. Fredericson *et al* (2000) have consequently postulated that fatigued runners or those who have a weak gluteus medius are therefore prone to increased thigh adduction and internal rotation at midstance, leading to an increased valgus vector at the knee, and that this increases tension on the ITB, making it more prone to impingement on the lateral epicondyle of the femur, especially during the early stance phase of gait (foot contact).

2.7. Pathology:

A point of friction, resulting in iliotibial band friction syndrome, is caused by the repetitive flexion and extension movements of the knee during running, which brings the thickest portion of the band, which is adjacent to the lateral femoral epicondyle, anterior to the axis of motion in the last 30 degrees of extension (Reid, 1992:424). (*Fig 2.2 B*).

The band moves posterior to the axis of the knee motion and the epicondylar prominence during flexion movements of more than 30 degrees (Reid, 1992:424). (*Fig 2.2 A*). The band remains tense in both these positions.

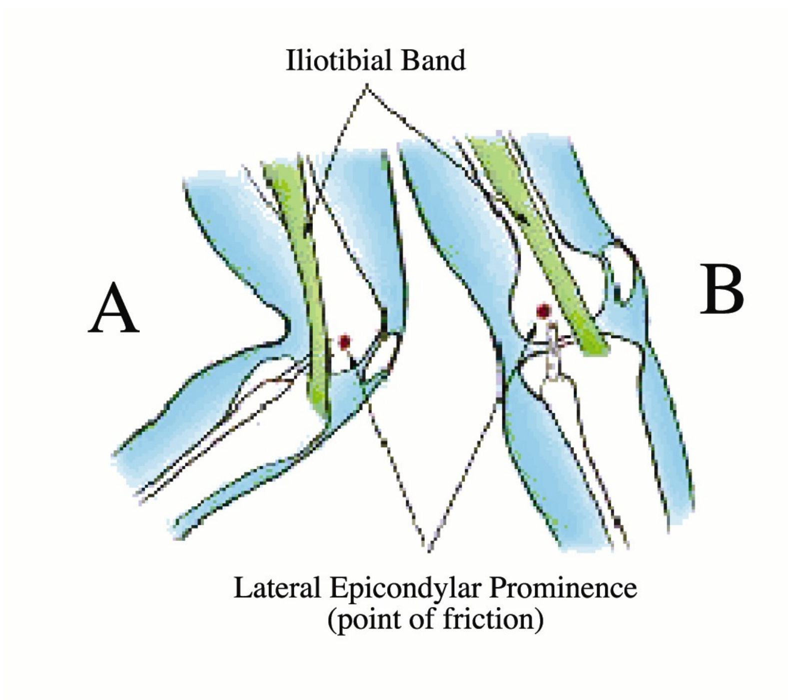


Figure 2.2 ITB movement during knee flexion/extension

The constant friction, as a result of overuse and other various biomechanical factors which will be discussed below in *2.8* under *"Aetiological Factors"*, results in irritation and inflammation of the tissue between the ITB and the lateral femoral epicondyle. Recent histopathologic studies (Nemeth *et al*, 1996; Nishimura *et al*, 1997) in patients with chronic ITBS show that the tissue under the ITB consists of synovium that is a lateral extension and invagination of the knee joint capsule, rather than a separate bursa as previously described in the literature by Renne (1975) and Orava (1978).

ITBS is more commonly seen in ectomorphs and mesomorphs (Sutker *et al*, 1985) probably due to the lack of underlying subcutaneous fat between the iliotibial band and the lateral femoral condyle. It is less common in females than in males most probably due to ligamentous laxity, a less prominent lateral epicondyle, and more subcutaneous fat present in women (Sutker *et al*, 1985).

2.8. Aetiological Factors:

A number of aetiological factors have been related to ITBS, a variety of which occur in presenting patients. Lindenberg *et al,* (1985) and Reid (1992:424-429) discuss the following aetiological factors: Training errors, which include increasing mileage too quickly, inadequate warm-ups, and road camber; Biomechanical factors, which include genu varum, foot hypersupination, -overpronation or cavus foot, leg length discrepancies, and sacroiliac – and fibular head fixations. Footwear with poor shock absorption has also been implicated (Baker, 1995) and most recently, hip abductor weakness (Fredericson *et al,* 2000).

These aetiological factors were found to ultimately result in excessive tautness of the ITB, and hence, the friction syndrome (Lindenberg *et al,* 1985; Noble *et al,* 1980; Reid, 1992:424-429).

2.9. Current Treatments :

Due to this variety of aetiologies, the treatment of ITBS has been multifactorial. Reid (1992:424-429) and Fredericson *et al,* (2000) outline the following treatments: The reduction of inflammation using ice and anti-inflammatories; reduction of tautness and myofascitis of the band employing stretch techniques and trigger point therapies; corrective actions involving easy training and avoidance of cambered roads and downhill running; and the correction of biomechanical abnormalities with orthotics, are all employed. Surgery is sometimes opted for in especially stubborn chronic cases, and involves snipping the posterior half of the band, where it rubs over the lateral femoral epicondyle (Martens *et al,* 1989).

Gluteus medius strengthening in the treatment of ITBS has been under research most recently (Fredericson *et al,* 2000), and has been shown to be an effective conservative treatment for ITBS.

2.10. Previous Studies:

Based on the aetiological factors discussed, the following studies were undertaken:

The clinical trial by Lindenberg *et al* (1985) investigated some of these aetiological factors in ITBS. Their objective was to identify runners at risk, and to direct treatment at correcting the causal factors. Thirty-six participants were treated and followed for at least one year. They found that in addition to a high incidence of genu varum alignment and a cavus foot type in their subjects, that road camber and hardness of shoes appear to be aetiological factors. They also found that treatment directed at correcting causal factors proved to be as effective as conventional conservative treatment of symptoms (ie. – rest, ice, stretch, and ultrasound.)

Hall (1997) investigated the effectiveness of myofascial trigger point (MFTP) therapy in ITBS, excluding any biomechanical abnormalities from consideration. The placebo-controlled study included 15 participants in a control group, which only received detuned ultrasound over active trigger points in the ITB and TFL. The 15 participants of the experimental group received dry needling of the active trigger points in the ITB and TFL, as well as stretch exercises. The results showed that the experimental group improved over the placebo group, and it was concluded that MFTP including stretch therapy may be an effective means of treatment for ITBS.

Wood (1997) investigated the effectiveness of chiropractic sacroiliac joint adjustment in the management of acute ITBS in long distance runners. A control group consisting of 15 participants were given ice therapy, orthotic shoe inserts, stretching exercises, and an alteration in running program. An experimental group were given the same, with the addition of a chiropractic sacroiliac joint manipulation. The comparative results between his experimental and control groups showed no convincing difference in effectiveness. It is doubtful whether a larger sample size would have yielded different results, because the treatment included so many techniques, with the sacroiliac joint adjustment added for the experimental group. Had the study focused more specifically on the effect of sacroiliac joint adjustment itself, some statistically significant results might have been obtained.

Baer (1999) mentions in a case report that level 4 Active Release Technique (Leahy, 1995) to the TFL and ITB, combined with sacroiliac joint and fibular head manipulations, proved to be quick and effective treatment for ITBS. The patient was seen for five sessions over a one-month period, with resolution of subjective and objective findings.

Baker (1995), and more recently Fredericson, Cookingham and Chaudhari *et al*, (2000), mention that hip abductors (the gluteus medius and TFL) are often weak on the affected side of ITBS compared to the uninjured side. Fredericson, Cookingham and Chaudhari *et al*, (2000), examined hip abductor strength in long-distance runners with ITBS, comparing their injured limb strength to their uninjured limb, and with unaffected runners. They also investigated whether correction of the strength deficits in the hip abductors of the affected runners through a rehabilitation program, correlated with a successful return to running. 30 participants were included in their 6 week rehabilitation program, specifically directed at hip abductor strengthening. It was found that 92% of the participants returned to running pain free at the end of the study, and at a 6 month follow-up, there were no reports of recurrence. It was concluded that long distance runners with ITBS have weaker hip abductor strength in the affected leg compared with their unaffected leg and with unaffected runners. Also, that symptom improvement with successful return to running parallels improvement in hip abductor strength.

Fredericson, Guillet and DeBenedictis (2000), also mention successful treatment of ITBS in runners by combining conventional conservative treatments with gluteus medius strengthening and stretching exercises.

The findings of Lindenberg *et al* (1985), Baker (1995), and Fredericson *et al,* (2000), therefore all point to a weakness/dysfunction of the hip abductors (mainly the gluteus medius) as a common factor in ITBS.

The literature reveals that the comparative effectiveness of this newly investigated ITBS treatment based on gluteus medius strengthening, to any other form of conservative treatment, requires further research. However, since it is already known that both techniques (i.e. stretching and strengthening) are indeed effective in the treatment of ITBS (Fredericson *et al,* 2000; Fredericson *et al*, 2002), it may prove more valuable, instead of investigating their relative effectiveness, to rather investigate the effect of both techniques in different combination, i.e. the combination of stretching followed by strengthening, compared to the combination of strengthening followed by stretching, of the gluteus medius and the ITB, in the rehabilitation of chronic ITBS.

Therefore, the aim of this research study was to determine the relative effectiveness of the combination of stretching followed by strengthening, compared to the combination of strengthening followed by stretching, of the gluteus medius and the ITB, in the rehabilitation of chronic ITBS in long distance runners.

2.11. Principles of stretching and strengthening exercises:

The ultimate objective from achieving optimum ITB flexibility as well as hip abductor strength is to reduce and manage ITB syndrome in the rehabilitation of chronic ITB syndrome in long distance runners, and to determine which of the two therapies should be practised first.

2.11.1. Basic Principles of Strengthening Exercises:

Maughan (1999:110-111) explains that strength training produces a number of effects in athletes. The initial physiologic adaptation responsible for increases in strength is neural. Due to the stimulus of strength or resistance training, neural adaptations include increases in motor unit recruitment, more effective motor learning, and improved muscle activation and co-ordination. Muscular adaptations follow, and include muscle fibre hypertrophy, which is due to a combination of increased muscle fibre size, increased amounts of connective tissue, and more extensive capillary vascular beds within muscle. A third adaptation to strength training is an increase in intramuscular fuel stores of Adenosine Triphosphate and glycogen.

Muscular hypertrophy of postural muscles decreases strain on ligamentous structures during prolonged activity (Zohn, 1988:128). This can be applied to strengthening of the pelvic stabilisers (the hip abductors – gluteus medius and TFL), thereby decreasing the strain on the ITB in long distance running.

Muscle endurance – the ability to perform repetitive contractions over a prolonged period of time – is essential in long distance running, and increases in muscle strength result in increases in muscle endurance (Arnheim and Prentice, 1993:48). Therefore, strengthening the weak hip stabilisers/hip abductors found in runners with ITBS, may also improve the endurance of these muscles and enable them to work optimally during long distance running, thereby removing one of the underlying causes of ITBS.

The strengthening exercise employed in this study is a combination of isometric and isotonic exercise, and is discussed in detail in the annotated diagram of *Figure 3.2,* in chapter 3. Arnheim and Prentice (1993:50-51) discuss isometric and isotonic exercises, and mention that isometric exercise involves contracting a muscle in a static position, i.e. with no change in the length of the muscle while it contracts. Isotonic exercise involves the dynamic loading of a muscle, when the muscle shortens and lengthens while contracting. Isometric exercises are known to produce greater strength gains while isotonic exercises produce strength gains more evenly through all ranges of activity.

2.11.2. Basic Principles of Stretching Exercises:

Arnheim and Prentice (1993:63) explain that muscles which undergo strength training alone shorten, and this not only reduces their range of movement but in time makes them less efficient and more prone to injury. The negative effect that strength training alone has on joint mobility can be counteracted by flexibility training, of which stretching is one of the most important forms.

According to Burke (1986:47), flexibility can be defined as the ability of a joint to move through its normal range of motion. The structures that can limit this range of motion are (a) the bony architecture of the joint, (b) the ligaments surrounding the joint, (c) the fibrous joint capsule, and (d) the tendons and muscle that cross the joint. The most common cause of decreased flexibility is muscle contracture, or muscle tightness, and this cause of inflexibility is the easiest to resolve.

Wang (1993) and Sanders (1990:216) state that a number of factors that contribute to the flexibility of an individual have been identified. These include gender, age, muscle size, and warm-up. Anatomical differences between males and females may be responsible for the fact that females are generally more flexible than males. Flexibility also tends to decrease with age due to changes that occur in the structure of connective tissue. Muscle size also affects flexibility, with larger muscles usually demonstrating greater resistance to passive stretch than small muscles.

Sanders (1990:202) also mentions that improving flexibility allows the involved tissues to move easily to accommodate the stresses imposed on them, dissipate the impact of such stresses, and improve the effectiveness and efficiency of movement. Since the ability of connective and muscle tissue to absorb force is related to their flexibility, the greater their flexibility, the greater their ability to dissipate the applied force. The chance of stress-related injuries therefore decreases which translates into long-term, more effective training, and improved performance. This may be applied to long distance running, especially considering that between two and three times the body's weight is absorbed at every heel strike in the running gait cycle, and that between 500 and 600 heel strikes occur per kilometre (Reid, 1992:1131-1133).

Arnheim and Prentice (1993:46) explain that the neuromuscular component of stretching involves the stretch reflex. Muscle Spindles and Golgi Tendon Organs are two of the receptor types found in muscle. When a muscle is suddenly stretched, muscle spindles produce a reflex resistance to the stretch. This is a protective mechanism that acts to prevent or resist the muscle being excessively stretched and injured. However, with static or prolonged stretches that are held for between 6 and 60 seconds, the golgi tendon organs cause a reflex relaxation of the muscle, allowing the muscle to stretch through relaxation before extensibility limits are reached. Basmajian (1990:302) states that treatment of a muscle spasm must include a lengthening stretch as lengthening of tissues allows for dilatation of capillaries and results in increased bloodflow. Travell (1992:7) confirms that in the treatment of myofascial trigger points, passive stretching is an essential component.

The ultimate objective of stretch or flexibility training is therefore injury prevention, by improving and maintaining joint mobility, by decreasing the risk of joint overloading, by increasing muscle and tendon strength, and by adapting the musculoskeletal system to the demands of the particular sport that the athlete is involved in (Strauss, 1991:314).

Chapter Three

Materials and Methods

3.1. Study design and protocol:

This study was a quantitative, randomised, clinical trial, in the form of a pre-post, crossover design.
It included 30 participants with chronic ITBS who presented to the Durban Institute of Technology (DIT) Chiropractic Day Clinic. Posters advertising the study were displayed on notice boards at the DIT. The research was also presented at several running clubs around Durban, with free ITB assessments given during these presentations. All of those who responded to the advertisements and presentations were interviewed telephonically, or personally, as they presented to the clinic, to determine whether they complied with the selection criteria.

3.1.1. Standard of acceptance:

- Telephonic Interview as a Screening Process:

The following information was obtained either telephonically from interested participants, or directly from those who presented to the clinic:

- Participants had to have the characteristic signs and symptoms of ITBS: history of burning pain on the lateral side of the knee when running, and localised tenderness just above or below the lateral side of the knee.

- Participants had to have chronic ITBS (for at least 6 weeks), and must have successfully returned to at least 50% of their running performance compared to just before their ITB injury.
- Participants had to be between the ages of 18 and 50 years old.
- Participants may not have had previous surgical treatment for their ITBS.

The potential candidates who "passed" the telephonic or personal interview were then scheduled for an "initial consultation" during which they received a Patient Information Letter (Addendum A), informing them of the nature of the research, the selection criteria, and what would be required of them, should they be accepted into the study. They were subsequently required to sign an Informed Consent Form (Addendum B). The candidates underwent a Case History (Addendum C), a Physical Examination (Addendum D), and Knee- and Hip Regional Examinations (Addenda E and F respectively). These assessments, along with the inclusion and exclusion criteria discussed below, were used to finally accept 30 candidates for participation in the study.

3.1.2. Inclusion criteria:

In order to be accepted, the applicants had to fulfil the following criteria:

- All participants had to have the characteristic signs and symptoms of ITBS:

1. History of burning pain on the lateral side of the knee when running (Reid, 1992:424-429).
2. Localised point tenderness over the lateral femoral condyle, about 2-4cm above the lateral joint line (Reid, 1992:424-429).
3. Positive Noble's Compression Test (Noble *et al,* 1982).
4. Positive Modified Ober's test (Reid, 1992:424-429).

- All participants had to have had ITBS for at least 6 weeks. They had to have successfully recovered from the acute phase of the injury - the acute phase of ITBS cannot be effectively treated with the techniques employed in this study (Fredericson *et al,* 2000), and should instead be treated using the RICES protocol (i.e. Rest, Ice, Compression, Elevation, Strapping/Support) (Reid 1992:424-429; Fredericson *et al,* 2000).
- Participants had to have returned to at least 50% of their running performance, compared to their performance just before their ITB injury. This was a necessary factor for our rehabilitation-based intervention, and for homogeneity of the sample. This was done using a simple numerical rating scale of “Current Running Performance” vs. “Running Performance Before Injury” (see Addendum I). Each participant’s running performance before injury was given a rating of 100. Therefore, a current running performance score of at least 50 out of 100 was the requirement for selection into the study.
- All participants had to be at least 18 years of age, to prevent the inconvenience of parents or guardians having to accompany participants who were minors, at each visit. The literature reveals that previous studies have also only included adults – possibly for homogeneity of a sample of participants who have reached skeletal maturity. This remains to be investigated. Participants must also have been no older than 50 years of age, to minimise the inclusion of knees that commonly show signs of degenerative change by this age.
- Both males and females were included. The literature reveals no conclusive statistics that show a predominance of ITBS between the sexes. Most studies, like those of Lindenberg *et al* (1985), and Fredericson *et al* (2000), have used mixed samples of males and females with similar results for both sexes. This therefore, also remains to be investigated, taking into consideration the anatomical difference of a

greater Q-angle in females, which causes an increased varus alignment at the hip and an increased valgus alignment at the knee.

- All participants had to have gluteus medius weakness on the involved side/s (Baker, 1995 and Fredericson *et al,* 2000).
- All participants were required to agree to abide by the conditions set out in the Patient Information Letter (Addendum A) and complete the Informed Consent Form (Addendum B).

3.1.3. Exclusion criteria:

Applicants were excluded from the study for the following factors:

- If they had any other concomitant injuries, or other physical or biomechanical abnormalities, which may have been associated with their ITBS.
- Differential diagnoses including primary myofascial pain, early degenerative joint disease, lateral meniscal pathology, lateral collateral ligament pathology, superior tibiofibular joint sprain, popliteal or biceps femoris tendonitis, common peroneal nerve injury, or referred pain from the lumbar spine (Fredericson *et al,* 2000). These conditions were ruled out with a careful history and the relevant orthopaedic examinations.
- If they received any other form of treatment for their ITBS while participating in this study. This included the taking of non-steroidal anti-inflammatories and analgesics. Participants who had had previous surgical treatment for ITBS were also excluded from the study.
- If they suffered from any confirmed anxiety disorders or neuroses. These disorders have the potential to affect one's pain perception.
- Participants who were found to have any neurological deficits with which their signs and symptoms of ITBS may be related, or similarly any systemic disease, were also excluded from the study.

An initial set of data was recorded for each patient during the initial consultation. This consisted of the following tests, which are discussed in detail in *3.2 "Materials and Measurements":*

A) Subjective Measurements –
1. Short-form McGill Pain Questionnaire
2. Numerical Rating Scale-101

B) Objective Measurements –
1. Modified Ober's Test
2. Noble's Compression Test
3. Hip Adduction Angle
4. Hip Abduction Angle
5. Gluteus Medius Strength Test
6. Point Tenderness

C) Running Performance –
1. ITB Questionnaire
2. Daily Exercise Diary

3.2. Materials and Measurements:

3.2.1. Subjective Measurements:

These consist of the Short-form McGill Pain Questionnaire, and the Numerical Rating Scale-101 Questionnaire.

3.2.1.1 Short-form McGill Pain Questionnaire: (Addendum G)

According to Melzack (1987:197), the Short-form McGill Pain Questionnaire measures the patient's perception of the intensity and quality of their pain giving a sensory dimension of pain. "It is the most widely used measuring test for pain providing valuable information on the sensory, affective and evaluative dimension of pain experience" (Melzack, 1987:197).

The questionnaire took about 2-3 minutes to administer. It consists of 15 types of descriptive words that were rated on an intensity scale of:
0 = none, 1 = mild, 2 = moderate, and 3 = severe. The total score was then reflected as a percentage (Melzack, 1987:197).

3.2.1.2 Numerical Rating Scale-101 Questionnaire: (Addendum H)

The patient's perception of their pain intensity level is recorded on a numerical scale from 1 to 100, with 0 being no pain and 100 being the worst pain. The patient indicates by means of a percentage on a 10cm line, when the pain was at it's worst and again on another 10cm line when the pain was at it's least. The average of these two figures indicates the average pain experienced by the patient as a percentage.

Jensen *et al,* (1986:121) state that the NRS-101 questionnaire is regarded as a superior measuring instrument, being extremely easy to administer and score. It can be done either in written or verbal form, and due to its simplicity, there are very low tendencies for incorrect responses from patients.

3.2.2. Objective measurements:

3.2.2.1 Modified Ober's test:

ITB tightness is elicited by this test. As described in Reid (1992:426-427), the test was performed as follows:
The patient was made to lie laterally recumbent with the affected side uppermost. The affected lower limb was then brought into full extension by the examiner, with some abduction at the hip. In the Ober's test, the knee is flexed at this moment during the test, while in the Modified Ober's test, the knee is left extended. The examiner then slowly releases support of the limb, allowing the limb to fall into adduction past the neutral position. This constitutes a normal or negative test. A tight ITB restricts adduction and prevents the knee from falling past the neutral position. This constitutes a positive test for ITB tightness.

3.2.2.2 Noble's Compression test:

As described in Reid (1992:425), the test was performed as follows:
The patient was made to lie supine with the affected knee flexed to 90 degees. Pressure was placed over the proximal part of the lateral femoral condyle. The knee was then gradually extended, and at 30 to 40 degrees, if the patient complained of a similar pain to that experienced while running, then the test was positive for ITBS.

3.2.2.3 Gluteus Medius Strength test:

As described in Reider (1999:189), hip abduction strength was tested as follows:

The patient was made to lie laterally recumbent with the affected side facing up, and the hips and knees extended. The patient was asked to abduct the affected limb. A downward force was then exerted by the examiner against the limb, instructing the patient to resist the examiner's attempt to push the limb back down toward the table. Normally, a patient should be able to offer maximal resistance with firm control for at least 5 seconds.

The ideal method of measuring muscle strength is done with a digital manual muscle tester (Fredericson *et al,* 2002). It was unfortunately not possible to obtain this equipment due to the study's limited budget. This test was therefore performed according to the method described by Reider above, using time (seconds) that a maximal muscle contraction could be held firmly and steadily for, as the unit of measurement.

3.2.2.4 Digital Inclinometer:

A digital inclinometer was used during the Modified Ober's test to measure hip adduction as an indication of ITB flexibility.

"The use of an inclinometer to measure hip adduction using both the Ober test and the modified Ober test appears to be a reliable method for the measurement of ITB flexibility" (Bandy and Reese, 2003).

During each measurement session, participants were positioned lying down with their symptomatic side facing up. The inclinometer was positioned at the popliteal fossa of the knee on the involved side using a Velcro strap to hold it securely in place, and hip adduction was measured using the modified Ober's test. If the limb was horizontal, it was considered to be at 0 degrees, if below horizontal (adducted), it was recorded as a positive number, and if above horizontal (abducted), it was recorded as a negative number (Bandy and Reese, 2003).

In addition, hip abduction angle was also measured, with the intention of possibly finding a relationship between hip abductor strength, and hip abduction angle.

The dual inclinometer used was:
The Dualer Lite. Manufacturer: JTech Medical Industries, 357 West 910 South, Heber City, Utah, USA.

3.2.2.5 Algometer:

An algometer, also known as a pressure or force gauge is used for the assessment of local pain sensitivity. It has been widely used to evaluate pain in conditions varying from fibrositis to abdominal pain, and even in psychological research (Fischer, 1986:836).

The algometer is a force gauge fitted with a rubber disc having a surface area of 1cm2. Pressure is applied to a defined surface on the body through the rubber disc. The gauge is calibrated in lb/cm2. The device consists of a body attached to a metal rod with a male tread on the end, onto which the rubber disc is attached. Pressure exerted on the rod moves the indicator in a clockwise direction around the dial on the body. Pressing the zeroing button returns the indicator to zero after each measurement. The achieved force value is held until the zeroing button is pressed (maximum hold function) allowing a reading even after the meter is removed from the body (Fischer, 1986:836).

When the measurements were taken on the participants, they were first educated on the gauge and how it worked. They were told that after determining the area of maximum tenderness by palpation - along the ITB, 2-4 cm above the lateral joint line of the knee (Noble *et al,* 1982) - the algometer would be placed on it. The pressure would slowly be increased until the pressure sensation turned to pain (pain threshold point) at which stage the patient must verbalise that such a change has taken place. If a patient were to grimace or pull away, this was considered a later sign of pain (pain reaction point) than a verbal response and measurements were retaken (Fischer, 1986:837; Reeves *et al,* 1986:316).

The higher the pressure reading on the algometer, the less tender the area under investigation is, and a lower reading indicates a greater tenderness (Fischer, 1986:836).

3.2.3. Running Performance:

The effect on participants' running performance was measured using the ITB Questionnaire (Addendum J). The Daily Exercise Diary was used to monitor participant compliance and ability to perform the exercises. (Addendum K)

The ITB Questionnaire and Daily Exercise Diary were designed by the author of the study (Wood, 1997) for the measurement of patient disability specifically for ITBS. These have been used in this study merely as standardised measurement tools to monitor patient progression over time.

3.3. Intervention:

3.3.1. Treatment procedure and frequency:

As discussed above, 30 candidates were finally selected as participants during the Initial Consultation. Each participant was then randomly assigned to a group "C" or "G" during the Initial Consultation. This was done by the participant simply selecting a piece of paper marked either "C" or "G" out of a brown paper bag.

The participant then immediately received a first treatment which, depending on the his/her grouping, involved the following:

- The demonstration and practice of the Stretching Exercise protocol for group “C”. (see *Fig 3.1*)
- The demonstration and practice of the Strengthening Exercise protocol for group “G”. (see *Fig 3.2*)
- Instructions for completing the “ITB Questionnaire” (Addendum J), and “Daily Exercise Diary” entries (Addendum K) for both groups “C” and “G”.

All participants then received weekly “Follow-Up” Visits, which involved re-assessment to monitor their progression (i.e. the taking of all the subjective, objective, and performance measurements as described above in *3.2 “Materials and Measurements”*, as well as treatment in the form of the supervised performance of the Stretching Exercises for group “C”, and the Strengthening Exercises for group “G”.

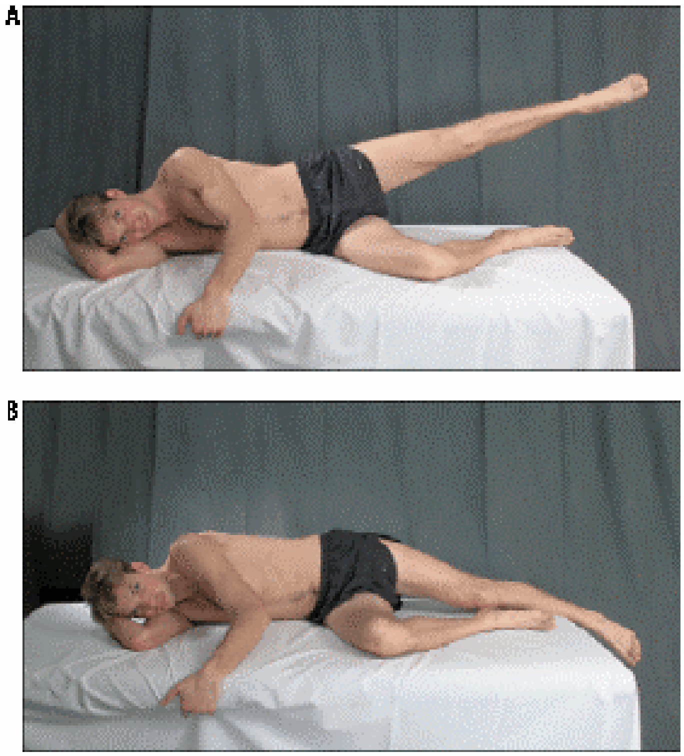
Both groups received 3 weeks of their respective exercise therapies, and then crossed over, exchanging treatment techniques. In the first visit following a participant’s crossing over, he/she was instructed on the new exercise, then practised and performed the exercise under the author’s supervision, and subsequently received 3 weekly “Follow-Up” visits, as they did for their previous set of exercises in their first period of the program.

The stretching and strengthening techniques employed in this study are those that have been proven effective, in the studies conducted by Fredericson, Guillet and DeBenedictis (Fredericson *et al,* 2000). The pictures shown below with instructions are the exercises that the participants were required to perform.
The two groups received these pictures and instructions only when it was their respective stretching or strengthening period during the study, thereby keeping them blind to their second exercise for their second period of the study, until it was their time to cross over.

Figure 3.1 Stretching Exercise

ITB stretching was done with a foam bolster to address especially tight areas. While supporting the upper body with the hands on the floor, the participant was made to recline on the foam bolster placed under the side of the involved leg, which was held straight. The patient was made to cross the uninvolved leg over the involved leg, and roll over the foam bolster from hip to knee, emphasizing tight areas. Participants were required to perform 3 sets of 3 repetitions daily (as in the study by Fredericson *et al,* 2000) and to check their compliance thereof in the “Daily Exercise Diary”.

Figure 3.2 Strengthening Exercise



Side-lying leg lifts were performed to strengthen the gluteus medius. Participants were instructed to keep the lower leg flexed for balance, and the upper (involved) leg straight, with slight external rotation. The involved leg was then abducted about 30 degrees, and the position held for 1 second (A). The leg was then slowly lowered and held in full adduction for 1 second (B). Participants were started on 1 set of 15 repetitions per day, building up to a goal of 3 sets of 30 reps per day, by increasing 5 reps per day, provided they had no soreness the next day (as in the study by Fredericson *et al,* 2000). As with the performance of the stretch exercise, participants were required to check their compliance of their strengthening exercise performance in the "Daily Exercise Diary".

No interruption in the individual running routines of the participants was made.
All subjects were however required to stop their runs immediately at the onset of pain, to prevent exacerbation of the condition. They were each supplied with a Daily Exercise Diary and an ITB Questionnaire, which were handed in at each follow-up visit (i.e. at weekly intervals).

3.4. Statistical Analysis:

3.4.1. Introduction:

Data analysis was done in SPSS version 11.0 and STATA version 8.0.
The data collected consisted of Categorical variables (eg: gender, ITB grade, Ober's Test and Noble's Test), and Numerical or Continuous variables (all other data).

Baseline data comparisons (data collected at the Initial Consultation) were done with chi-squared tests or Fisher's exact tests where appropriate, between the categorical baseline variables and the group to which the participant was assigned. Numerical baseline variables were compared between groups using a non-parametric Mann-Whitney test, due to the skewed distributions of most of the numerical variables and the sample size of 30.

Follow-up measurements were described by means of proportion of negative results by group over time in the case of categorical outcomes (Ober's test and Noble's test), and median values by group over time in the case of numerical outcomes.

3.4.2. Discussion of Analysis of Crossover Studies:

In the article on "Computer-Aided Analysis of Crossover Studies" (Dallal G.E, 2000), the author explains that there are three main factors to consider in a two treatment, two period crossover trial. These are Period Effect, Treatment Effect, and Group Effect.

"Treatment Effect" in this study, refers to the effect of Stretching compared to the effect of Strengthening (stretching and strengthening being the two treatments involved in this study).

"Period Effect" in crossover studies has two levels: Period 1 being the first three weekly Follow-Ups in this study, and Period 2 being the second three weekly Follow-Ups in this study. The Period Effect is therefore the effect from Period 1 for Group "G" compared to the effect from Period 2 for Group "C", as well as the effect from Period 1 for Group "C" compared to the effect from Period 2 for Group "G". (*Table 3.1*)

Group	Period 1	Period 2
"G"	Strengthening	Stretching
"C"	Stretching	Strengthening

Table 3.1 Period Effect

"Group Effect" in this study, refers to the effect of having been in Group "G" (having received strengthening before stretching), compared to the effect of having been in Group "C" (having received stretching before strengthening).

In the two treatment, two period crossover study, the Treatment effect, Period effect and Group effect may also be represented as "aliases" (two names for the same thing).
Treatment effect may be represented by "Group by Period" (Group*Period).
Period effect may be represented by "Group by Treatment" (Group*Treatment)
Group effect may be represented by "Treatment by Period" (Treatment*Period)

3.4.3. Statistical Analysis of the Data:

Analysis of Period, Treatment and Group Effects for Numerical outcomes was done in SPSS using Repeated Measures ANOVA (Analysis of Variance) on the log-transformed values. Values at the 3^{rd} week of the 1^{st} period and the 3^{rd} week of the 2^{nd} period were used to represent period 1 and period 2 values. Control for confounders (Hip Adduction angle) was achieved by including the confounder as a factor in the model.

Analysis of Period, Treatment and Group Effects for Categorical outcomes was done in STATA version 8 using GEE models (Generalised Estimating Equation), and controlling for ITB grade as a confounder.

Both the ANOVA and GEE applications are parametric models that provide a repeated measures outcome, with ANOVA providing a result for the Numerical data (mean over time) and GEE providing a result for the Categorical or binary data (Ober's test and Noble's test) over time.

These parametric statistics were chosen as a relatively normal distribution of data was assumed. Parametric statistics are also more powerful, with the repeated measures ANOVA and the GEE model being the only applications that provide analysis within and between two groups, as is required in a crossover study (Dallal G.E, 2000).

Chapter Four

Results

The results obtained from the statistical analysis of the collected data are presented in this chapter.

4.1. Baseline analysis:

This section shows a comparison of all baseline data for both groups (data collected at the Initial Consultation), as displayed in Table 4.1.

Table 4.1 Comparison of Baseline Data

Baseline variable	**Test used**	**p value for group comparison**	**Interpretation**
Gender	Fisher's exact	0.272	No significant difference in genders between the groups.
Grade of ITB	Chi squared	0.050	Significant association between grade of ITB and group (95% level). Group "G" had higher grade of ITB.
Age	Mann-Whitney U	0.683	No significant difference between the groups.
Ober's test	Fisher's exact	0.224	No significant difference between the groups.

Noble's test	Fisher's exact	-	Test could not be done as all were positive at baseline.
Gluteus medius strength	Mann-Whitney U	0.174	No significant difference between the groups
Hip adduction angle	Mann-Whitney U	0.002	Significant difference at 0.01 level (99%) between the groups
Hip abduction angle	Mann-Whitney U	0.653	No significant difference between the groups
Point tenderness	Mann-Whitney U	0.935	No significant difference between the groups
McGill pain score	Mann-Whitney U	0.126	No significant difference between the groups
Numerical pain scale	Mann-Whitney U	0.267	No significant difference between the groups
Running performance	Mann-Whitney U	0.775	No significant difference between the groups
Exercise performance	Mann-Whitney U	0.775	No significant difference between the groups

Most baseline variables did not show a statistically significant difference between the groups, except for ITB Grade (p value = 0.05) and Hip Adduction Angle (p value = 0.002). Group "G" was found to have a significantly higher ITB Grade overall and significantly lower Hip Adduction readings than Group "C". These two confounding variables have been controlled for in the statistical analysis of the data.

4.2. Follow-up over time - Period data:

This section shows a comparison of all the data collected at each weekly Follow-Up for both groups. The data has been tabulated, and then plotted in graph form, to show the progression of the two groups relative to each other, at each week of the study.

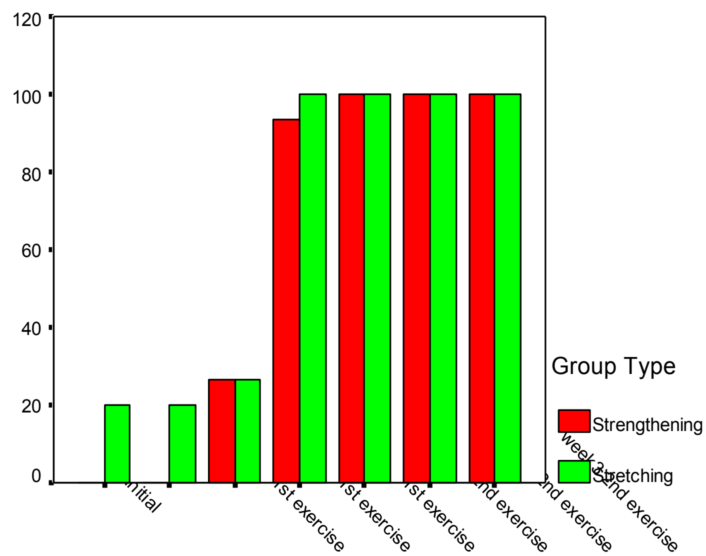
This section has been divided into parts A and B.
Part A shows the analysis of binary outcomes (results of Ober's tests and Noble's tests).
Part B shows the analysis of continuous outcomes (all other test results).

4.2A. Binary outcomes – Modified Ober's Test and Noble's Compression Test

Table 4.2.1 Results of Modified Ober's Test

Test	Time point	Result	Group G n (%)	Group C n (%)
Modified Ober's test	Initial	Positive	15 (100)	12 (80)
		Negative		3 (20)
	Week1-1st exercise	Positive	15 (100)	12 (80)
		Negative		3 (20)
	Week2- 1st exercise	Positive	11 (73.3)	11 (73.3)
		Negative	4 (26.7)	4 (26.7)
	Week3-1st exercise	Positive	1 (6.7)	
		Negative	14 (93.3)	15 (100)

	Week1-2nd exercise	Positive		
		Negative	15 (100)	15 (100)
	Week2- 2nd exercise	Positive		
		Negative	15 (100)	15 (100)
	Week3-2nd exercise	Positive		
		Negative	15 (100)	15 (100)



Graph 4.2.1 Comparison of Results – Modified Ober's Test

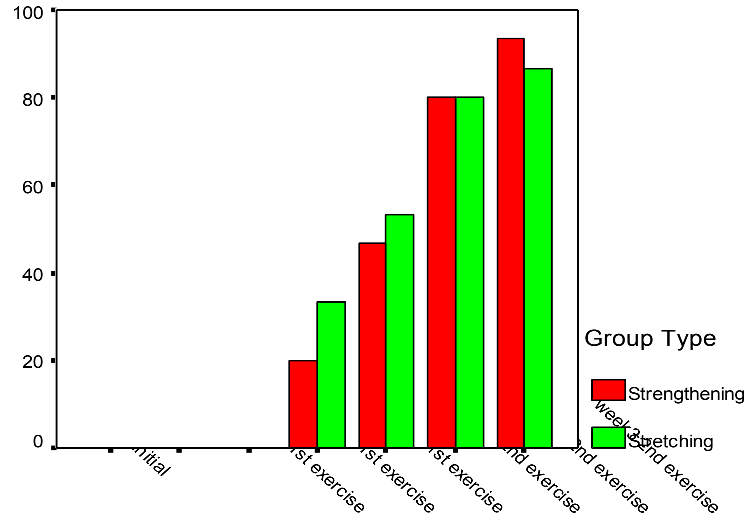
From graph 4.2.1 it can be seen that group "C" was 20% negative for Ober's test at the initial consultation, while Group "G" was 100% positive. By the final week of the first period (week 3), Group "G" showed a 93% improvement, while Group "C" showed an 80% improvement in the results of the Modified Ober's test. Therefore, for the first period, group "G", the group performing the strengthening exercises, had achieved better improvement for the outcome of the Modified Ober's test than Group "C", those who had performed the stretches.

For the second period, both groups were 100% negative for the Modified Ober's test throughout the period. There was therefore no difference between the groups' progressions for the second period.

Overall, Group "G" showed 100% improvement in their results of the Modified Ober's test, while Group "C" showed an 80 % improvement.

Table 4.2.2 Results of Noble's Compression Test

Test	Time point	Result	Group G n (%)	Group C n (%)
Noble's test	Initial	Positive	15 (100)	15 (100)
		Negative		
	Week1-1st exercise	Positive	15 (100)	15 (100)
		Negative		
	Week2-1st exercise	Positive	15 (100)	15 (100)
		Negative		
	Week3-1st exercise	Positive	12 (80)	10 (66.7)
		Negative	3 (20)	5 (33.3)
	Week1-2nd exercise	Positive	8 (53.3)	7 (46.7)
		Negative	7 (46.7)	8 (53.3)
	Week2-2nd exercise	Positive	3 (20)	3 (20)
		Negative	12 (80)	12 (80)
	Week3-2nd exercise	Positive	1 (6.7)	2 (13.3)
		Negative	14 (93.3)	13 (86.7)



Graph 4.2.2 Comparison of Results – Noble's Compression Test

From graph 4.2.2 it can be seen that both groups were 100% positive for Noble's Compression test at the initial consultation, and only showed improvement by the last week (week 3) of period 1, where Group "G" was 20% negative and Group "C" was 33% negative for Noble's test.

In the second period, Group "G" (performing the stretching) showed an overall improvement of 73% negative for Noble's test, and Group "C" (performing the strengthening) an overall improvement of 54% negative.

Therefore, it appears that for Noble's test, the stretching exercises produced better results in both periods 1 and 2. However, overall, Group "G" appears to have done better for Noble's test, with a best result of 93% negative by the last week, while Group "C" achieved a best result of 87% negative by the last week.

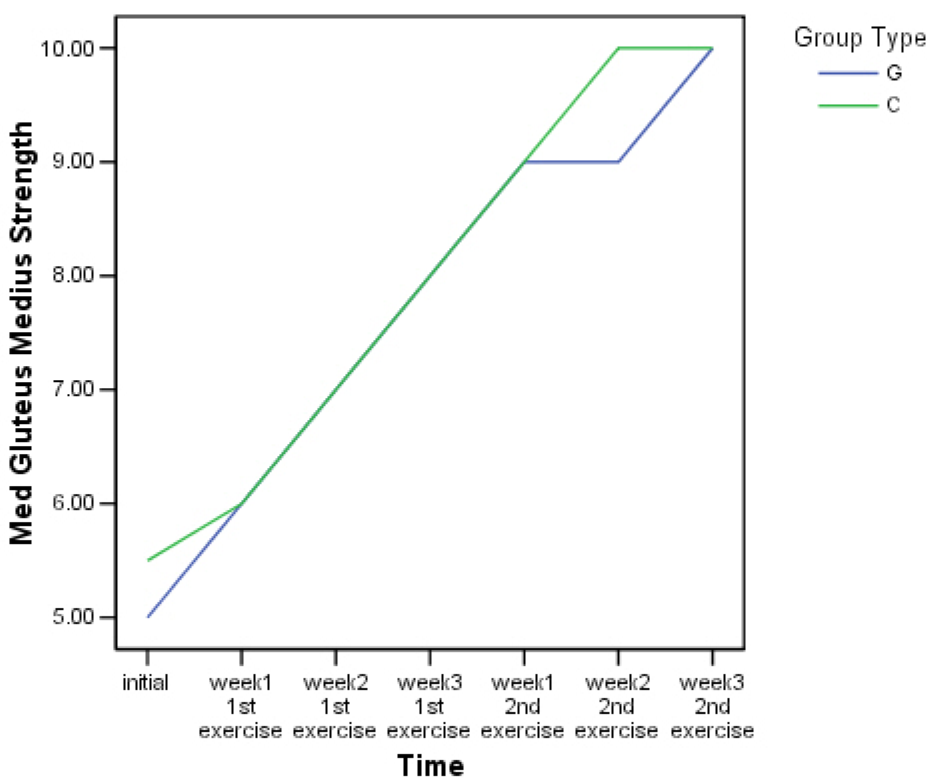
4.2B. Continuous Outcomes:

The following tables with their corresponding graphs show the comparative results of all numerical data for both groups, taken at each weekly Follow-Up. Results show the mean, median, range, and standard deviation for each test performed at each weekly Follow-Up visit, for both groups.

Table 4.2.3 Gluteus Medius Strength Test values

Group Type		Gluteus Medius Strength – Initial	Gluteus Medius Strength - Week 1 - 1st exercise	Gluteus Medius Strength - Week2 - 1st exercise	Gluteus Medius Strength - Week3 - 1st exercise	Gluteus Medius Strength - Week 1 - 2nd exercise	Gluteus Medius Strength - Week 2 - 2nd exercise	Gluteus Medius Strength - Week 3 - 2nd exercise
Group G	Mean	5.1333	5.7000	6.9667	8.6000	9.2333	9.3000	10.0667
	N	15	15	15	15	15	15	15
	Std. Deviation	2.31815	2.36643	2.86896	2.82337	2.75724	2.74382	2.90853
	Median	5.0000	6.0000	7.0000	8.0000	9.0000	9.0000	10.0000
	Range	9.00	9.00	12.00	10.50	10.00	10.50	9.50
Group C	Mean	5.7667	5.9333	6.6667	8.1333	8.6333	10.2333	11.1000
	N	15	15	15	15	15	15	15
	Std.	1.5682	1.6568	1.2051	1.6087	2.4013	3.1558	2.9350

	Deviation	9	8	5	6	9	7	1
	Median	5.5000	6.0000	7.0000	8.0000	9.0000	10.0000	10.0000
	Range	4.00	4.50	4.00	5.50	7.50	9.50	7.50
Total	Mean	5.4500	5.8167	6.8167	8.3667	8.9333	9.7667	10.5833
	N	30	30	30	30	30	30	30
	Std. Deviation	1.97113	2.01068	2.16748	2.27025	2.55874	2.94412	2.91868
	Median	5.0000	6.0000	7.0000	8.0000	9.0000	9.5000	10.0000
	Range	9.00	9.00	12.00	10.50	10.50	10.50	9.50



Graph 4.2.3 Comparison of Results – Gluteus Medius Strength Test

Graph 4.2.3 shows that at the initial consultation, Group “C” had a median of 5.5 seconds for the Gluteus Medius Strength test, and Group “G”, a median of 5.0 seconds. For the first period, Group “G” showed a median improvement of 3 seconds, while Group C, a median improvement of 2.5 seconds for maintaining a maximal gluteus medius contraction. Therefore, the strengthening exercises appear to have produced better results for the Gluteus Medius Strength test in the first period.

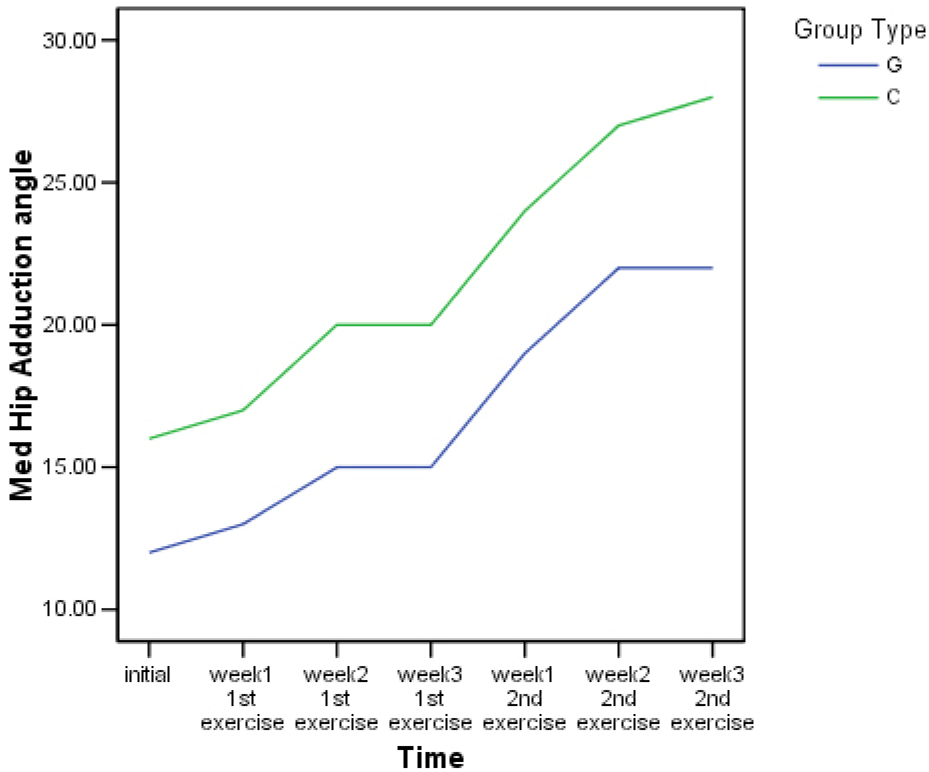
For the second period, both groups showed improvements of 2 seconds, both reaching a best result of 10 seconds by the last week.

Overall, Group “G” produced better results for gluteus medius strength, with a median total improvement of 10 seconds, while Group “C” showed a median total improvement of 9.5 seconds.

Table 4.2.4 Hip Adduction Angle values

Group Type		Hip Adduction angle – Initial	Hip Adduction angle - Week 1 - 1st exercise	Hip Adduction angle - Week 2 - 1st exercise	Hip Adduction angle - Week 3 - 1st exercise	Hip Adduction angle - Week 1 - 2nd exercise	Hip Adduction angle - Week 2 - 2nd exercise	Hip Adduction angle - Week 3 - 2nd exercise
Group G	Mean	12.4000	12.6667	14.1333	15.2000	17.8000	20.0000	21.2000
	N	15	15	15	15	15	15	15

	Std. Deviation	2.41424	2.58199	2.89992	3.16679	4.27952	4.56696	4.73890
	Median	12.0000	13.0000	15.0000	15.0000	19.0000	22.0000	22.0000
	Range	8.00	9.00	9.00	10.00	15.00	15.00	15.00
Group C	Mean	16.0000	16.6667	18.8000	19.9333	23.1333	25.8667	27.7333
	N	15	15	15	15	15	15	15
	Std. Deviation	3.29502	3.17730	3.42679	3.28344	3.54293	3.62268	3.30512
	Median	16.0000	17.0000	20.0000	20.0000	24.0000	27.0000	28.0000
	Range	11.00	10.00	11.00	10.00	12.00	12.00	11.00
Total	Mean	14.2000	14.6667	16.4667	17.5667	20.4667	22.9333	24.4667
	N	30	30	30	30	30	30	30
	Std. Deviation	3.37741	3.49713	3.91930	3.97998	4.71778	5.03048	5.21095
	Median	15.0000	15.0000	17.0000	18.5000	22.0000	24.0000	25.5000
	Range	13.00	13.00	14.00	14.00	17.00	17.00	19.00



Graph 4.2.4 Comparison of Results – Hip Adduction Angle

There was a significant difference in results for Hip Adduction Angle at the initial consultation (see *Table 4.1*). This difference in baseline results was controlled for in the analysis of the data.

Graph 4.2.4 shows a median of 12 degrees for Group "G", and a median of 16 degrees for Group "C" at the initial consultation. The graph then shows an almost identical course for both groups throughout the study, with group "C" having consistently higher values.

For the first period, Group "G" showed a median improvement of 3 degrees of hip adduction, while Group "C", a median improvement of 4 degrees. The stretching exercises therefore appear to have produced better improvement for hip adduction angle than the strengthening exercises, for the first period.

For the second period, Group "G" (performing the stretches) showed a median improvement of 7 degrees of hip adduction, while Group "C" (performing the strengthening exercises) showed a median improvement of 8 degrees of hip adduction.

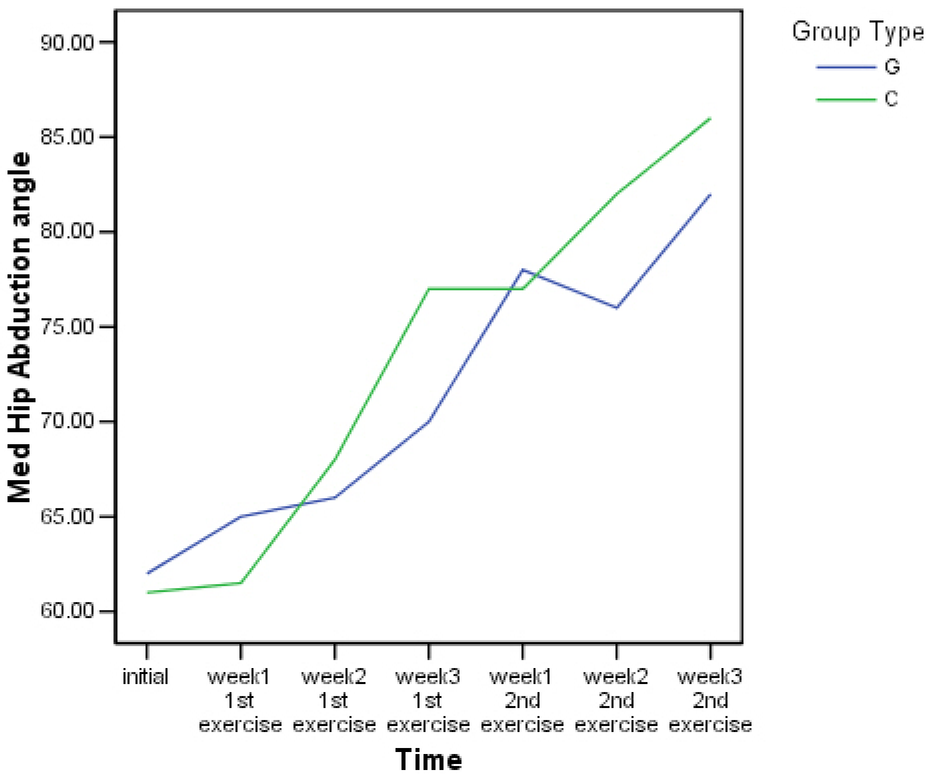
Therefore, for the second period, the strengthening exercises appear to have produced better improvement for hip adduction angle than the stretches.

Overall, Group "C" produced better results in hip adduction angle, with a median total improvement of 12 degrees, while Group "G" showed a median total improvement of 10 degrees.

Table 4.2.5 Hip Abduction Angle values

Group Type		Hip Abduction angle - initial	Hip Abduction angle - Week 1 - 1st exercise	Hip Abduction angle - Week 2 - 1st exercise	Hip Abduction angle - Week 3 - 1st exercise	Hip Abduction angle - Week 1 - 2nd exercise	Hip Abduction angle - Week 2 - 2nd exercise	Hip Abduction angle - Week 3 - 2nd exercise
Group G	Mean	59.0667	61.0000	67.2000	72.8667	72.6667	76.8000	80.1333
	N	15	15	15	15	15	15	15
	Std. Deviation	14.46901	14.84684	13.58150	14.52518	12.33848	11.95348	10.91439
	Media	62.000	65.000	66.000	70.000	78.000	76.000	82.000

	n	0	0	0	0	0	0	0
	Range	51.00	54.00	49.00	55.00	38.00	41.00	40.00
Group C	Mean	62.3333	62.7857	70.1333	76.9333	79.4000	83.4667	85.8667
	N	15	14	15	15	15	15	15
	Std. Deviation	9.75168	10.60608	10.86848	10.03185	8.11348	7.58633	8.36546
	Median	61.0000	61.5000	68.0000	77.0000	77.0000	82.0000	86.0000
	Range	45.00	47.00	43.00	34.00	30.00	29.00	30.00
Total	Mean	60.7000	61.8621	68.6667	74.9000	76.0333	80.1333	83.0000
	N	30	29	30	30	30	30	30
	Std. Deviation	12.23660	12.77756	12.17780	12.43840	10.81660	10.40469	9.98965
	Median	61.5000	62.0000	66.5000	73.5000	77.5000	82.0000	85.5000
	Range	55.00	57.00	58.00	55.00	51.00	56.00	53.00



Graph 4.2.5 Comparison of Results – Hip Abduction Angle

Shown in graph 4.2.5, Group "G" had a median hip abduction angle of 62 degrees at the Initial Consult, and Group "C", a median of 61 degrees.

For the first period, Group "G" showed a median improvement of 8 degrees of hip abduction and Group "C", a median improvement of 16 degrees. It therefore appears that the stretching exercises produced a better improvement for hip abduction angle than the strengthening exercises, during the first period.

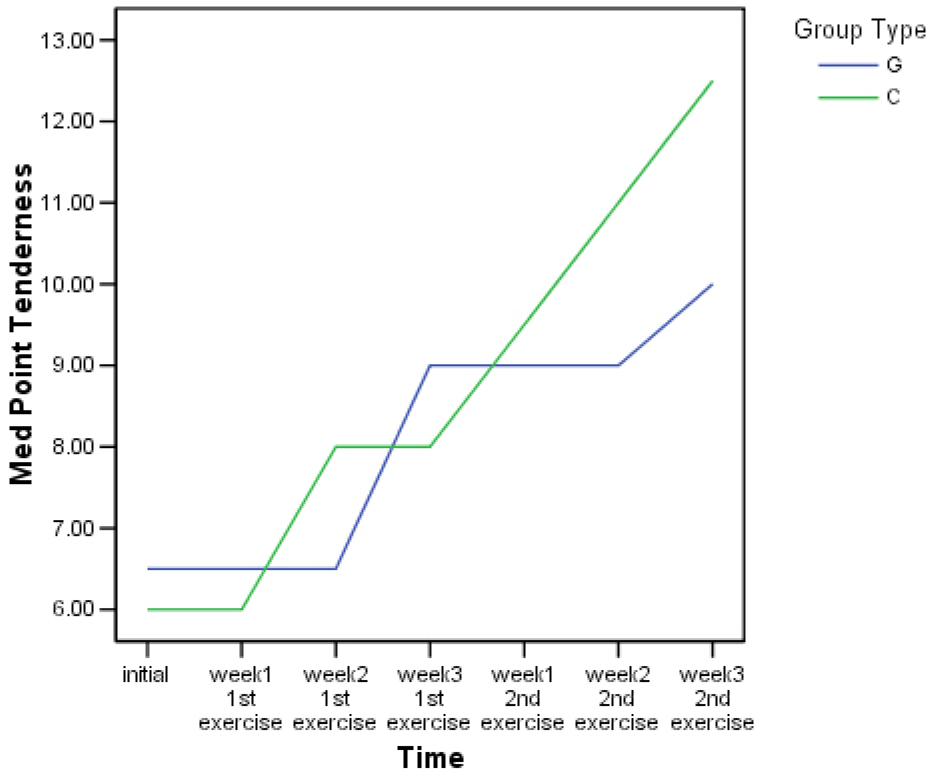
For the second period, Group "G" (performing the stretches) showed a median improvement of 12 degrees of hip abduction with a best result of 82 degrees during the last week. Group "C" (performing the strengthening exercises) showed a median improvement of 9 degrees of hip abduction, with a best result of 86 degrees during the last week. It therefore appears that the stretching exercises produced better improvement for hip abduction angle than the strengthening exercises, for the second period also.

Overall, Group "C" produced better results in hip abduction angle with a median total improvement of 25 degrees, compared to a median total of 20 degrees for Group "G".

Table 4.2.6 Point Tenderness values

Group Type		Point Tenderness - Initial	Point Tenderness - Week 1 - 1st exercise	Point Tenderness - Week 2 - 1st exercise	Point Tenderness - Week 3 - 1st exercise	Point Tenderness - Week 1 - 2nd exercise	Point Tenderness - Week 2 - 2nd exercise	Point Tenderness - Week 3 - 2nd exercise
Group G	Mean	6.4000	6.8333	7.5433	9.1333	9.1233	9.4067	10.3500
	N	15	15	15	15	15	15	15
	Std. Deviation	2.24563	2.23340	2.14050	2.08589	1.39295	1.56409	1.79732
	Median	6.5000	6.5000	6.5000	9.0000	9.0000	9.0000	10.0000
	Range	6.50	7.00	7.50	7.30	6.00	6.50	6.00
Group C	Mean	6.2333	6.2667	8.3867	9.0000	9.8000	10.8733	11.6933
	N	15	15	15	15	15	15	15
	Std.	1.8695	1.8211	2.1892	2.3528	2.5128	2.0158	1.6390

	Deviati on	6	7	2	1	2	2	2
	Media n	6.0000	6.0000	8.0000	8.0000	9.5000	11.000 0	12.500 0
	Range	6.50	6.50	7.00	7.00	8.00	6.20	5.20
Total	Mean	6.3167	6.5500	7.9650	9.0667	9.4617	10.140 0	11.021 7
	N	30	30	30	30	30	30	30
	Std. Deviati on	2.0320 0	2.0229 3	2.1701 4	2.1857 4	2.0256 8	1.9232 9	1.8229 2
	Media n	6.2500	6.5000	7.0000	8.7500	9.0000	9.6500	10.650 0
	Range	6.50	7.00	8.00	7.50	8.00	7.50	6.00



Graph 4.2.6 Comparison of Results – Point Tenderness

Shown in graph 4.2.6, Group "G" began the study with a median point tenderness of 6.5lb/cm2, and Group "C", a median of 6.0 lb/cm2.

For the first period, Group "G" showed a median improvement of 2.5 lb/cm2 in point tenderness, while Group "C" showed a median improvement of 2.0 lb/cm2. Therefore, it appears that the strengthening exercises produced better improvement in point tenderness than the stretches, for the first period.

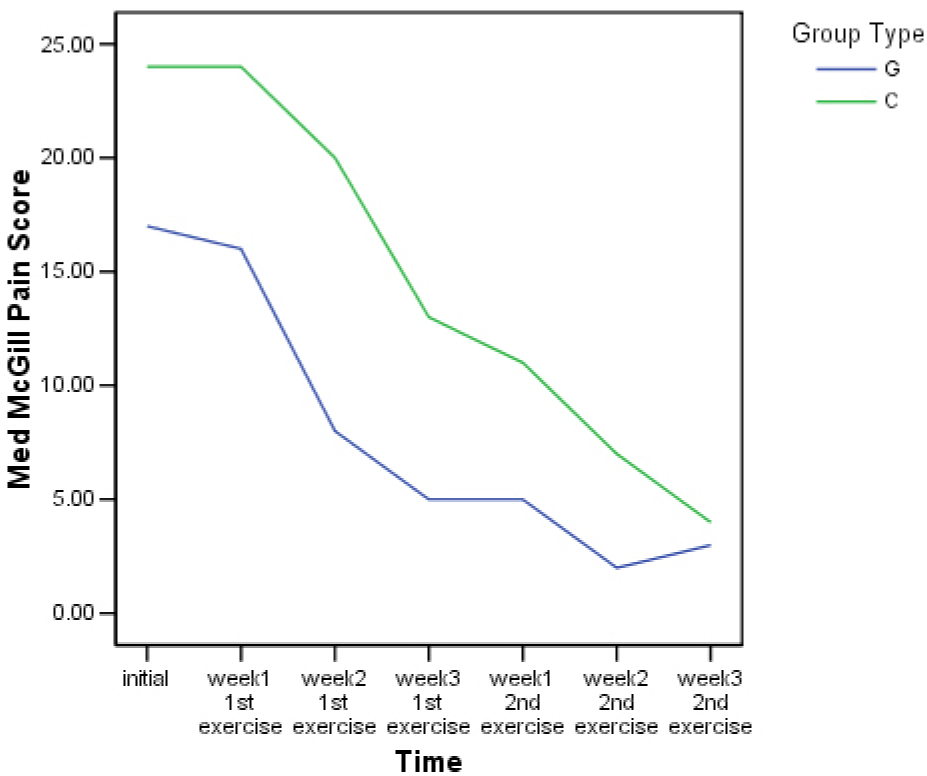
For the second period, Group "G" (performing the stretches) showed a median improvement of 1lb/cm2 in point tenderness, while Group "C" (performing the strengthening exercises) showed a median improvement of 4.5 lb/cm2. The strengthening exercises therefore appear to have produced better improvement in point tenderness than the stretches for the second period as well.

Overall, Group “C” produced better results for point tenderness, with a median total improvement of 6.5 lb/cm2, while Group “G” had a median total improvement of 3.5 lb/cm2.

Table 4.2.7 Short-form McGill Pain Questionnaire values

Group Type		McGill Pain Score - initial	McGill Pain Score - Week 1 - 1st exercise	McGill Pain Score - Week 2 - 1st exercise	McGill Pain Score - Week 3 - 1st exercise	McGill Pain Score - Week 1 - 2nd exercise	McGill Pain Score - Week 2 - 2nd exercise	McGill Pain Score - Week 3 - 2nd exercise
Group G	Mean	20.2667	18.6667	11.0667	7.4667	5.5333	4.1333	2.6000
	N	15	15	15	15	15	15	15
	Std. Deviation	10.74022	10.60772	6.29588	6.77038	4.98378	5.98649	2.55790
	Median	17.0000	16.0000	8.0000	5.0000	5.0000	2.0000	3.0000
	Range	37.00	38.00	24.00	26.00	21.00	25.00	10.00
Group C	Mean	32.0000	32.0000	26.6000	17.7333	16.0667	11.8667	7.2667
	N	15	15	15	15	15	15	15
	Std. Deviation	23.40635	23.40635	23.44842	17.39239	16.63674	13.05957	9.49787
	Media	24.000	24.000	20.000	13.000	11.000	7.0000	4.0000

	n	0	0	0	0	0		
	Range	87.00	87.00	89.00	64.00	60.00	51.00	31.00
Total	Mean	26.1333	25.3333	18.8333	12.6000	10.8000	8.0000	4.9333
	N	30	30	30	30	30	30	30
	Std. Deviation	18.86199	19.09926	18.62716	13.97930	13.20240	10.72863	7.23465
	Median	21.0000	20.0000	13.0000	9.0000	7.0000	4.0000	3.0000
	Range	90.00	91.00	95.00	64.00	64.00	51.00	31.00



Graph 4.2.7 Comparison of Results: Short-form McGill Pain Questionnaire

Graph 4.2.7 shows that at the initial consultation, Group “G” had a median McGill Pain score of 17 points, and Group “C”, a median of 24 points.

For the first period, Group “G” showed a median improvement of 12 points, while Group “C” showed a median improvement of 11 points. The strengthening exercises therefore produced better McGill pain scores, compared to the stretches for Group “C”.

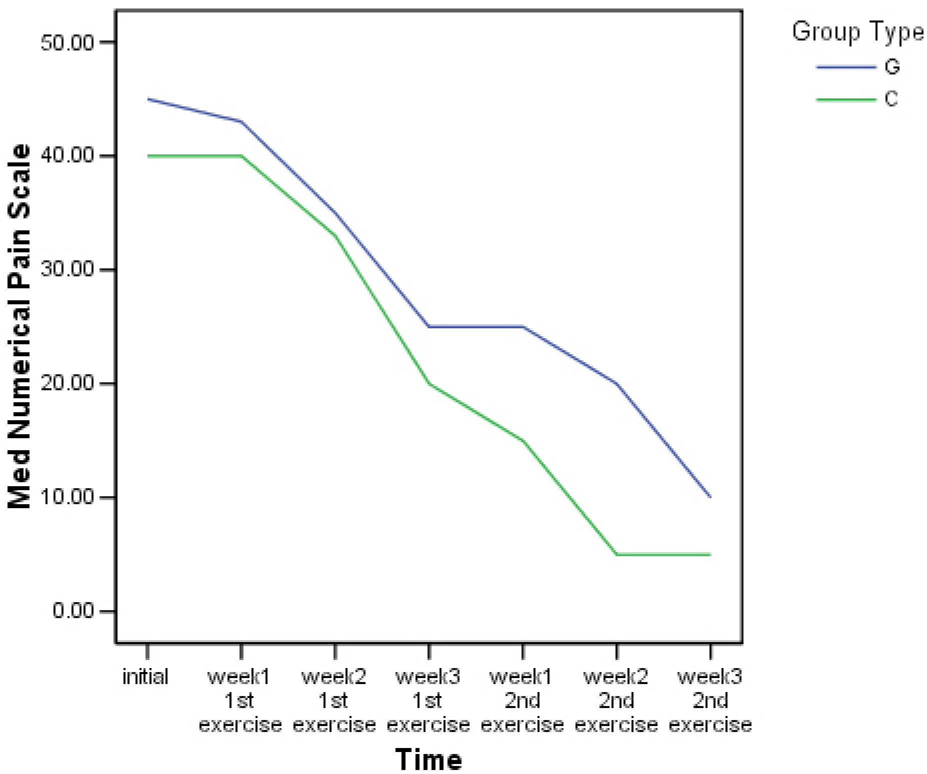
For the second period, Group “G” (performing the stretches) showed a median improvement of 2 points, while Group “C” (performing strengthening exercises) showed a median improvement of 9 points. Therefore, the strengthening exercises again produced better McGill pain scores than the stretches.

Overall, Group “C” produced better McGill pain scores, with a median total of 20 points, while Group “G” showed a median total improvement of 14 points.

Table 4.2.8 Numerical Rating Scale-101 values

Group Type		Numerical Pain Scale – Initial	Numerical Pain Scale - Week 1 - 1st exercise	Numerical Pain Scale - Week 2 - 1st exercise	Numerical Pain Scale - Week 3 - 1st exercise	Numerical Pain Scale - Week 1 - 2nd exercise	Numerical Pain Scale - Week 2 - 2nd exercise	Numerical Pain Scale - Week 3 - 2nd exercise
Group G	Mean	45.8667	42.5333	31.5333	24.0000	19.6000	16.1333	8.9333
	N	15	15	15	15	15	15	15

	Std. Deviation	16.59977	13.87632	14.92776	13.49074	11.20459	9.41023	6.82921
	Median	45.0000	43.0000	35.0000	25.0000	25.0000	20.0000	10.0000
	Range	77.00	62.00	54.00	42.00	35.00	30.00	20.00
Group C	Mean	39.1333	39.1333	34.8667	22.6000	17.5333	13.0667	9.4000
	N	15	15	15	15	15	15	15
	Std. Deviation	16.11063	16.11063	16.50051	16.24720	14.79801	13.48791	11.70348
	Median	40.0000	40.0000	33.0000	20.0000	15.0000	5.0000	5.0000
	Range	53.00	53.00	63.00	55.00	48.00	40.00	40.00
Total	Mean	42.5000	40.8333	33.2000	23.3000	18.5667	14.6000	9.1667
	N	30	30	30	30	30	30	30
	Std. Deviation	16.43325	14.87438	15.55280	14.69025	12.93934	11.53286	9.41782
	Median	42.5000	40.5000	34.0000	25.0000	20.0000	15.0000	5.5000
	Range	77.00	62.00	67.00	55.00	50.00	40.00	40.00



Graph 4.2.8 Comparison of Results – Numerical Rating Scale-101

Graph 4.2.8 shows that at the initial consultation, Group "G" had a median numerical pain rating of 45 points, and Group "C", a median of 40 points.

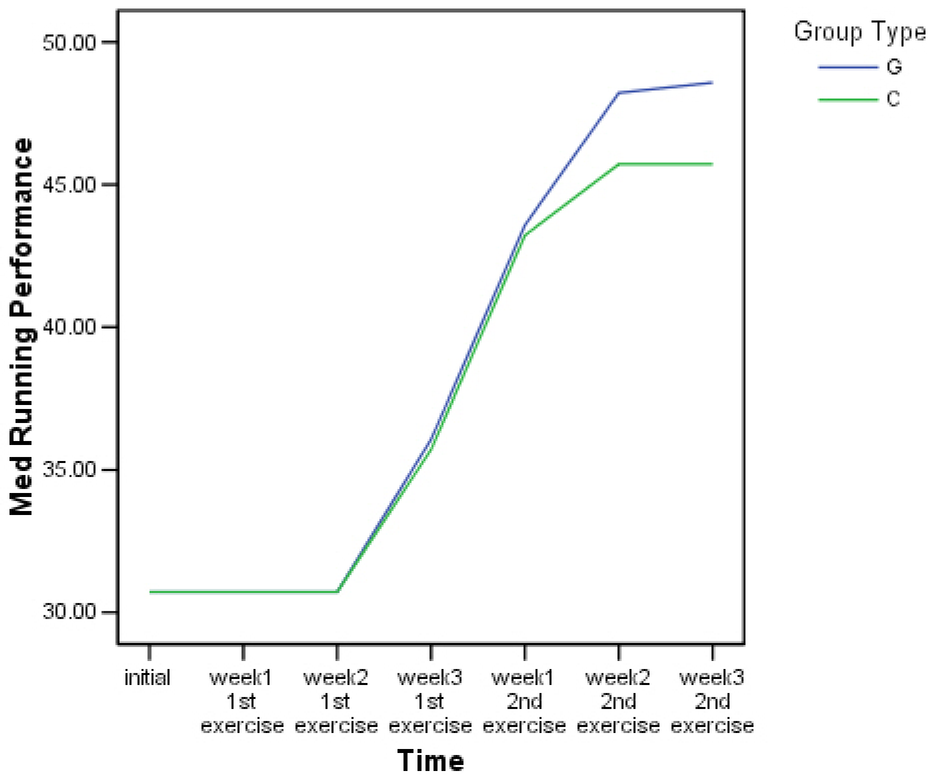
For the first period, both groups showed a median improvement of 20 points.
For the second period, both groups showed a median improvement of 15 points.
The stretches and strengthening exercises therefore produced the same improvement for both groups for each period of the study.

Overall, both groups showed a median total improvement of 35 points for the numerical pain rating scale.

__Table 4.2.9 Running Performance (ITB Questionnaire) values__

Group Type		Running Performance – initial	Running Performance - Week 1 - 1st exercise	Running Performance - Week 2 - 1st exercise	Running Performance - Week 3 - 1st exercise	Running Performance - Week 1 - 2nd exercise	Running Performance - Week 2 - 2nd exercise	Running Performance - Week 3 - 2nd exercise
Group G	Mean	33.4100	33.4100	35.6007	41.4347	47.9600	52.1507	56.1747
	N	15	15	15	15	15	15	15
	Std. Deviation	10.73457	10.73457	11.18891	15.09218	14.39664	14.51337	17.30153
	Median	30.7200	30.7200	30.7200	36.0800	43.5800	48.2200	48.5800
	Range	41.08	41.08	36.08	47.86	45.00	43.22	61.44
Group C	Mean	33.2927	33.2927	34.1240	36.1240	44.0533	47.2680	51.9587
	N	15	15	15	15	15	15	15
	Std. Deviation	10.87119	10.87119	11.63854	11.70970	13.40066	14.43117	16.97860
	Median	30.7200	30.7200	30.7200	35.7200	43.2200	45.7200	45.7200
	Range	35.72	35.72	35.72	35.72	51.08	55.36	56.08
Total	Mean	33.3513	33.3513	34.8623	38.7793	46.0067	49.7093	54.0667
	N	30	30	30	30	30	30	30

	Std. Deviation	10.61537	10.61537	11.24249	13.54430	13.80934	14.43577	16.97862
	Median	30.7200	30.7200	30.7200	35.7200	43.5800	46.0800	48.5800
	Range	41.08	41.08	41.08	57.86	57.86	58.22	66.44



Graph 4.2.9 Comparison of Results – Running Performance

Graph 4.2.9 shows that at the initial consultation, both groups had median running performance scores of 30.72.

For the first period, Group “G” showed a median improvement of 5.36 points, while Group “C” showed a median improvement of 5.00 points. The strengthening exercises therefore produced better running performance scores than the stretches for the first period.

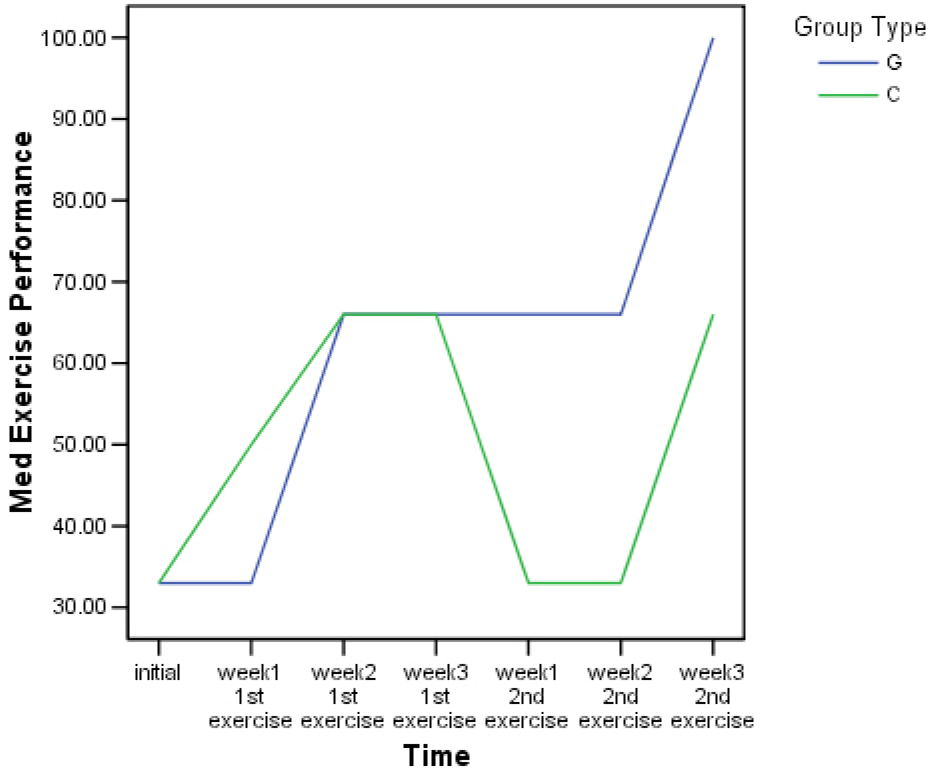
For the second period, Group “G” (performing the stretches) showed a median improvement of 12.50 points, while Group “C” (performing the strengthening exercises) showed a median improvement of 10.00 points. Therefore, for the second period, the stretching exercises produced better running performance scores than the strengthening exercises.

Overall, Group “G” produced better running performance scores, with a median total of 17.86 points, while Group “C” showed a median total improvement of 15.00 points.

Table 4.2.10 Exercise Performance – Daily Exercise Diary values

Group Type		Exercise Performance - initial	Exercise Performance - Week 1 - 1st exercise	Exercise Performance - Week 2 - 1st exercise	Exercise Performance - Week 3 - 1st exercise	Exercise Performance - Week 1 - 2nd exercise	Exercise Performance - Week 2 - 2nd exercise	Exercise Performance - Week 3 - 2nd exercise
Group G	Mean	34.1533	42.9333	58.4667	71.8000	57.2667	78.5333	88.6667
	N	15	15	15	15	15	15	15
	Std. Deviation	9.72896	15.03551	22.61752	21.69002	13.71895	18.58520	16.59030

	Median	33.0000	33.0000	66.0000	66.0000	66.0000	66.0000	100.0000
	Range	49.00	33.00	67.00	67.00	33.00	50.00	34.00
Group C	Mean	33.0000	46.4000	66.2000	75.0667	33.0000	41.8000	62.7333
	N	15	15	15	15	15	15	15
	Std. Deviation	.00000	12.83856	16.71697	15.56308	.00000	15.10534	9.19990
	Median	33.0000	50.0000	66.0000	66.0000	33.0000	33.0000	66.0000
	Range	.00	33.00	67.00	34.00	.00	33.00	33.00
Total	Mean	33.5767	44.6667	62.3333	73.4333	45.1333	60.1667	75.7000
	N	30	30	30	30	30	30	30
	Std. Deviation	6.78516	13.84977	19.93322	18.62272	15.59340	25.01735	18.64579
	Median	33.0000	33.0000	66.0000	66.0000	33.0000	66.0000	66.0000
	Range	49.00	33.00	67.00	67.00	33.00	67.00	67.00



Graph 4.2.10 Comparison of Results – Exercise Performance

Shown in graph 4.2.10, both groups began the study with a median of 33 points for exercise performance.

For the first period, both groups showed a median improvement in exercise performance of 33 points. For the second period, Group "G" (performing the stretches) showed a further median improvement of 33 points in exercise performance, while Group "C" appeared to have struggled with the performance of the strengthening exercise, losing a median of 33 points during week 1 of the second period, and then gaining their performance of 33 points back by the last week of the study.

Overall, Group "G" produced better exercise performance scores, with a median total of 66 points, while Group "C" showed a median total improvement of 33 points.

4.3. *Analysis of Period, Treatment and Group effects:*

From the intra-group and inter-group analysis of the period, treatment and group effects, it was determined whether the Null Hypothesis (Ho) or the Alternative Hypothesis (Ha) has applied to:

a) the objective clinical findings,

Ho: There is no difference between the two groups in the objective clinical findings on analysis of the data.

Ha: There is a difference between the two groups in the objective clinical findings on analysis of the data.

b) the subjective clinical findings,

Ho: There is no difference between the two groups in the subjective clinical findings on analysis of the data.

Ha: There is a difference between the two groups in the subjective clinical findings on analysis of the data.

c) the performance findings,

Ho: There is no difference between the two groups in the performance findings on analysis of the data.

Ha: There is a difference between the two groups in the performance findings on analysis of the data.

The null hypothesis shall be rejected at the α level of significance ($\alpha = 0.05$) if $p \leq \alpha$. Therefore, if the p value for an outcome is found to be less than or equal to 0.05, it is concluded that there is a statistically significant difference between the two groups for the outcome tested. Conversely, if the p value for an outcome is found to be greater than 0.05, it is concluded that there is no statistically significant difference between the two groups for the outcome tested.

This section has been divided into parts A and B.

Part A discusses the analysis of binary outcomes (results of Ober's tests and Noble's tests).

Part B discusses the analysis of continuous outcomes (all other test results).

4.3A. Binary outcomes – Noble's Compression Test and Modified Ober's Test

Table 4.3 p values for Noble's Compression Test results

Outcome	**Covariate**	**p value**
Noble's test	Period	0.022
	Group	0.426
	Period*group (treatment effect)	0.322

Noble's Compression test has shown a statistically significant period effect (p value = 0.022), but no statistically significant treatment effect (p value = 0.322) or group effects (p value = 0.426). Both groups showed significant improvement for both periods, regardless of which of the two treatments they had received, or the order in which they had received them (see *Graph 4.2.2*), and the null hypothesis is therefore accepted for Noble's Compression test.

For the Modified Ober's test, no convergence was achieved on the GEE model. This was due to the fact that all subjects apart from one had a negative Ober's test at the end of the first period, and all subjects had a negative test at the end of the second period (see *Graph 4.2.1*).

This implies that with Modified Ober's test there was a statistically significant period effect, but no statistically significant treatment or group effects. Both groups showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them, and the null hypothesis is therefore tentatively accepted for the Modified Ober's test.

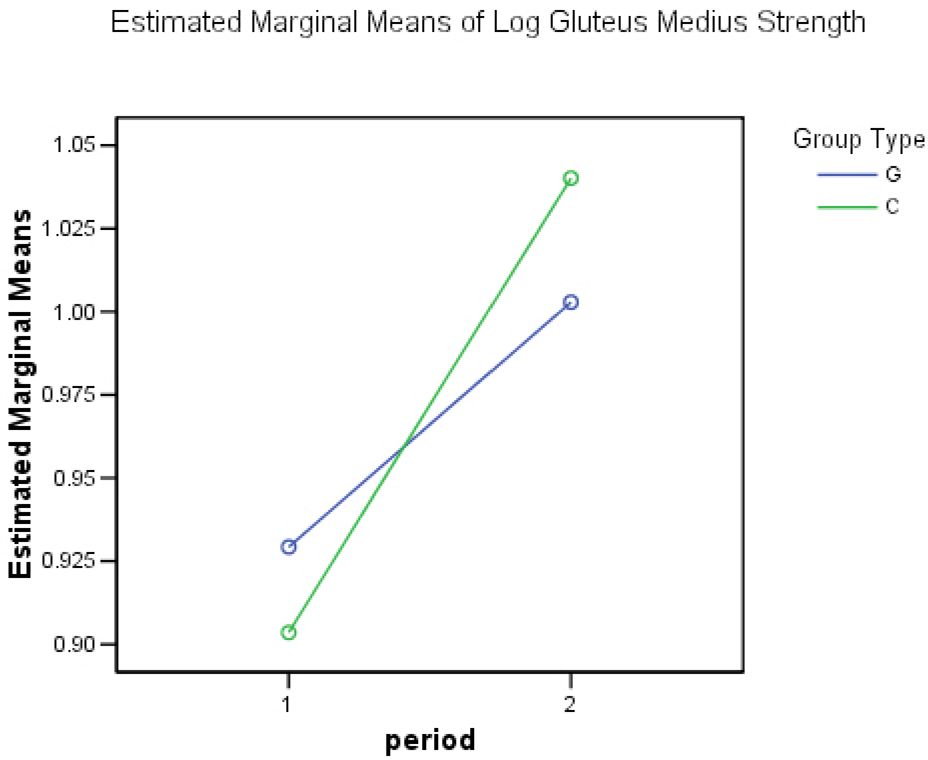
4.3B. Continuous Outcomes

Data analysis was done on the log-transformed values of the 3rd week in each period for both groups. The confounding effect of the difference in ITB grade and Hip Adduction Angle between the two groups' baseline data was controlled for by using ITB grade and Hip Adduction Angle as factors in the model.

4.3.1 Gluteus Medius Strength Test:

Effect	**p value**
Period	<0.001
Treatment (group*period)	0.213
Group (order of treatments)	0.594

Table 4.3.1 p values for Gluteus Medius Strength Test results



Graph 4.3.1 Group comparisons between Periods 1 and 2 for Log Gluteus Medius Strength

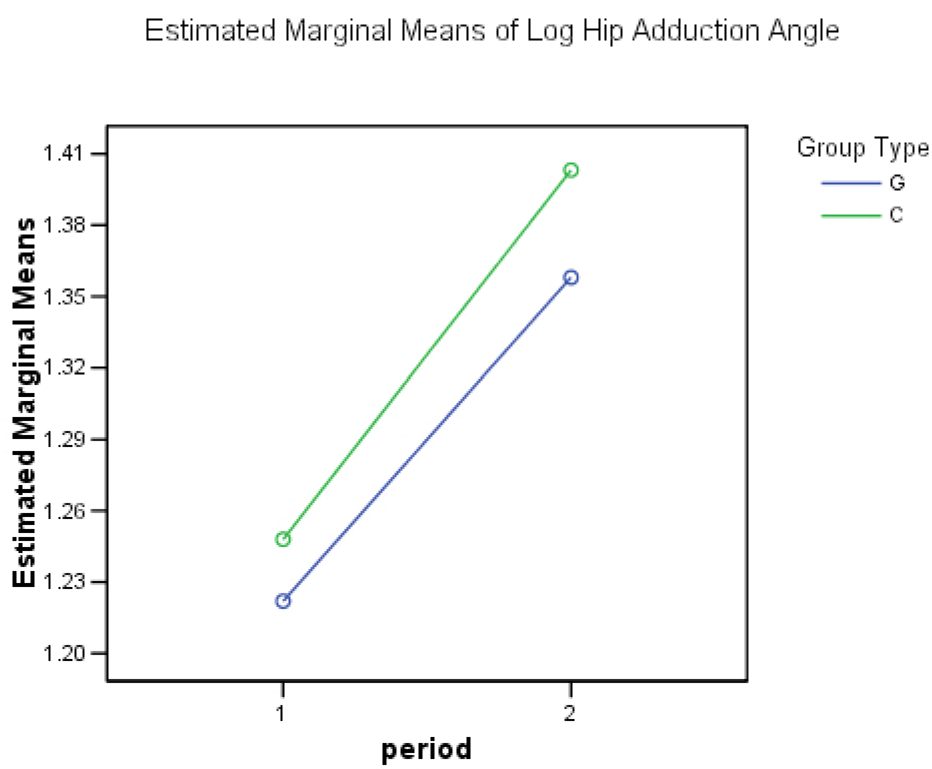
The above table and graph indicate that Gluteus Medius strength showed only a statistically significant period effect (p value = <0.001). There was no statistically significant difference in effect of the different treatments (treatment effect, p value = 0.213) or of the order of treatments (group effect, p value = 0.594).

Both groups showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them, and the null hypothesis is therefore accepted for the Gluteus Medius Strength Test.

4.3.2 Hip Adduction Angle:

Effect	p value
Period	<0.001
Treatment (group*period)	0.150
Group (order of treatments)	0.098

Table 4.3.2 p values for Hip Adduction Angle results



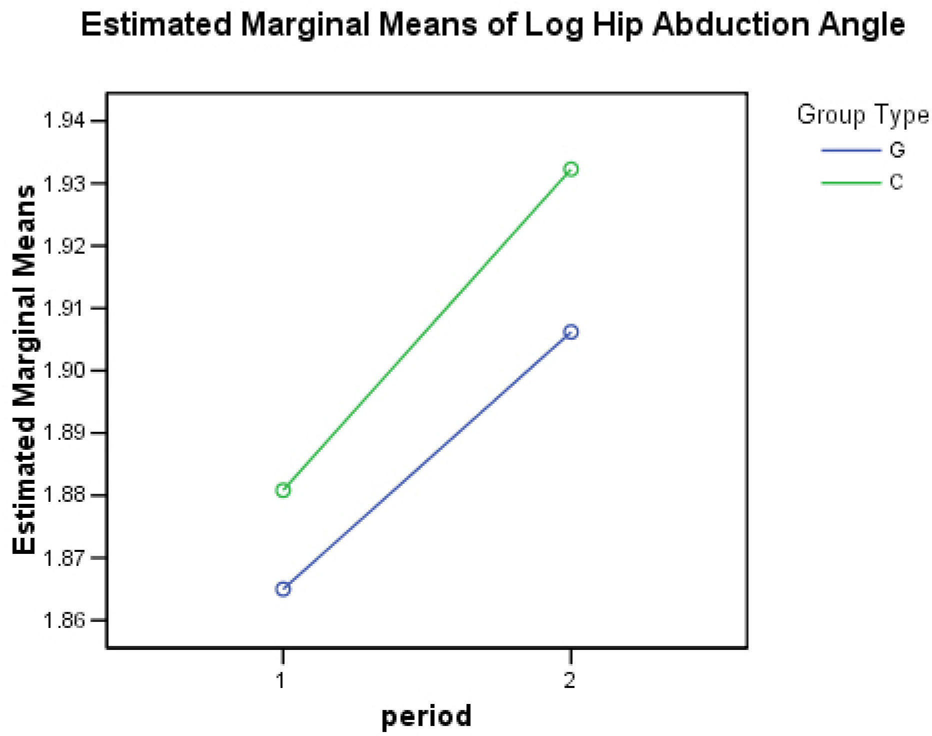
Graph 4.3.2 Group comparisons between Periods 1 and 2 for Log Hip Adduction Angle

Analysis of Hip Adduction Angle included the baseline measurement of hip adduction angle as a covariate to control for significant baseline differences found between the groups. The above table and graph indicate that there was a statistically significant period effect (p value = <0.001), and only a marginally non-significant group effect (p value = 0.098). The treatment effect was also found to be statistically non-significant (p value = 0.150). There were thus no differences in effectiveness between the treatments or the order in which they were applied, and the null hypothesis is therefore accepted for Hip Adduction Angle.

4.3.3 Hip Abduction Angle:

Effect	**p value**
Period	<0.001
Treatment (group*period)	0.762
Group (order of treatments)	0.538

Table 4.3.3   p values for Hip Abduction Angle results



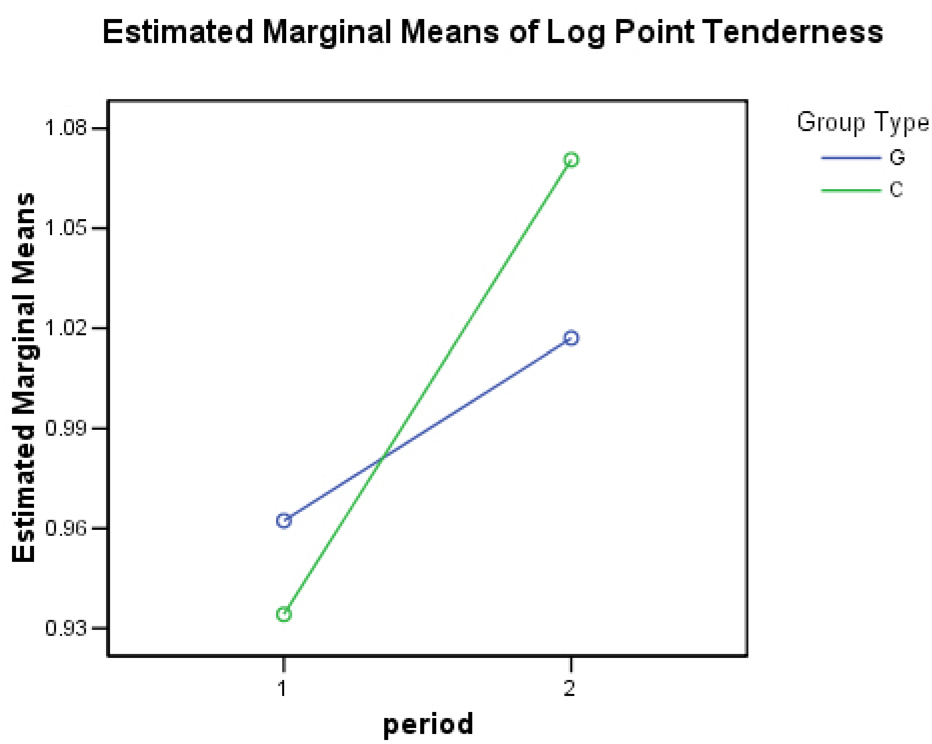
Graph 4.3.3 Group comparisons between Periods 1 and 2 for Log Hip Abduction Angle

There was a statistically significant period effect (p value = <0.001), but no statistically significant differences in group effect (p value = 0.538) or treatment effect (p value = 0.762) between the groups. Graph 4.3.3 indicates that both groups showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them, and the null hypothesis is therefore accepted for Hip Abduction Angle.

4.3.4 Point Tenderness (Algometer readings):

Effect	p value
Period	<0.001
Treatment (group*period)	0.049
Group (order of treatments)	0.528

Table 4.3.4 p values for Point Tenderness results



Graph 4.3.4 Group comparisons between Periods 1 and 2 for Log Point Tenderness

The above table and graph indicate that there is a statistically significant period effect (p value = <0.001), and a marginally statistically significant treatment effect (p value = 0.049) in favour of the strengthening exercises.

Graph 4.3.4 shows that from period 1, Group "G" (performing the strengthening exercises) had better point tenderness results compared to Group "C" (performing the stretches). From period 2, Group "C" (performing the strengthening exercises) showed better point tenderness results than Group "G" (performing the stretches). Therefore, the strengthening exercises produced better improvements in point tenderness in both periods, compared to the stretches, and the difference in treatment effect was statistically significant.

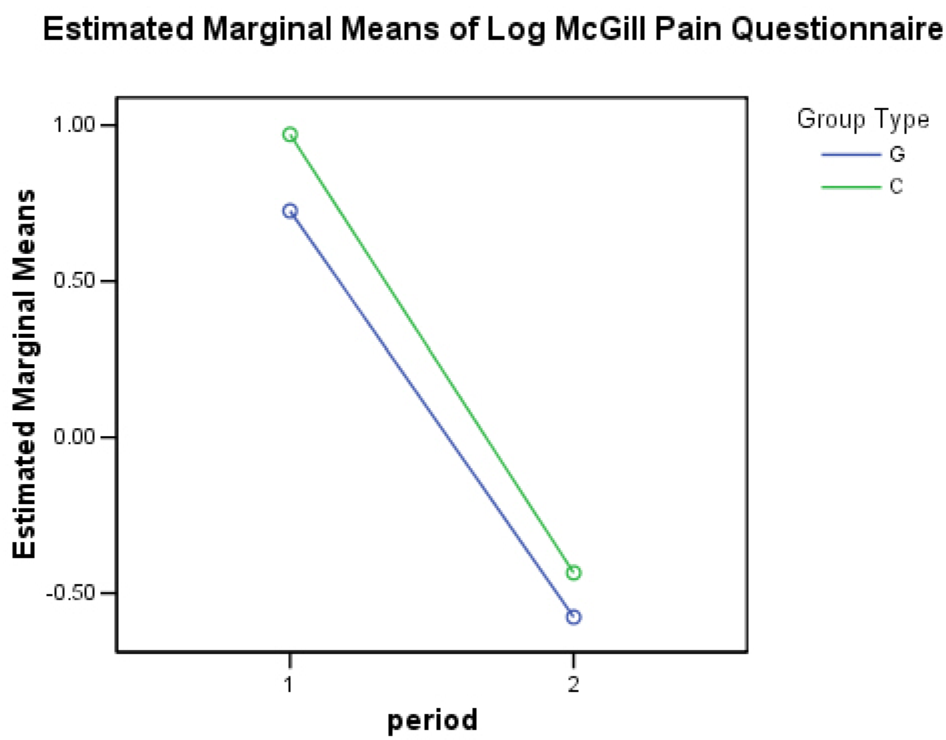
Overall, Group "C" showed a better result for point tenderness than Group "G" at the end of the study, but this difference in group effect was not statistically significant.

Even though there was a statistically significant difference in treatment effect favouring strengthening for the outcome of point tenderness, there was no statistically significant difference in group effect (the order in which the treatments were received), and the null hypothesis is therefore accepted for Point Tenderness.

4.3.5 Short-form McGill Pain Questionnaire:

Effect	p value
Period	<0.001
Treatment (group*period)	0.678
Group (order of treatments)	0.492

Table 4.3.5 p values for Short-form McGill Pain Questionnaire results



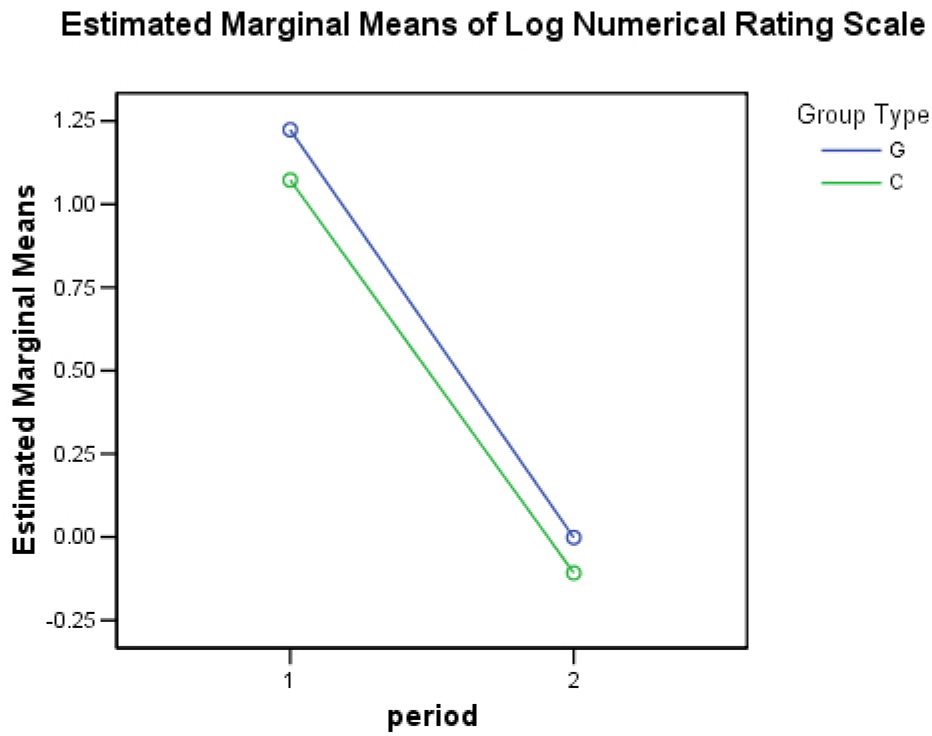
Graph 4.3.5 Group comparisons between Periods 1 and 2 for Log Short-form McGill Pain Questionnaire results

There was a statistically significant period effect (p value = <0.001), but no statistically significant group effect (p value = 0.492) or treatment effect (p value = 0.678). Graph 4.3.5 shows that there was no significant difference in McGill pain scores between Group "G" and Group "C", for whichever of the two treatments they had received, or whatever the order they had received the treatments. Participants' pain levels did significantly improve between the two periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome, and the null hypothesis is therefore accepted for the outcome of the Short-form McGill Pain Questionnaire.

4.3.6 Numerical Rating Scale-101:

Effect	**p value**
Period	<0.001
Treatment (group*period)	0.873
Group (order of treatments)	0.885

Table 4.3.6 p values for Numerical Rating Scale-101 results



Graph 4.3.6 Group comparisons between Periods 1 and 2 for Log Numerical Pain Rating-101

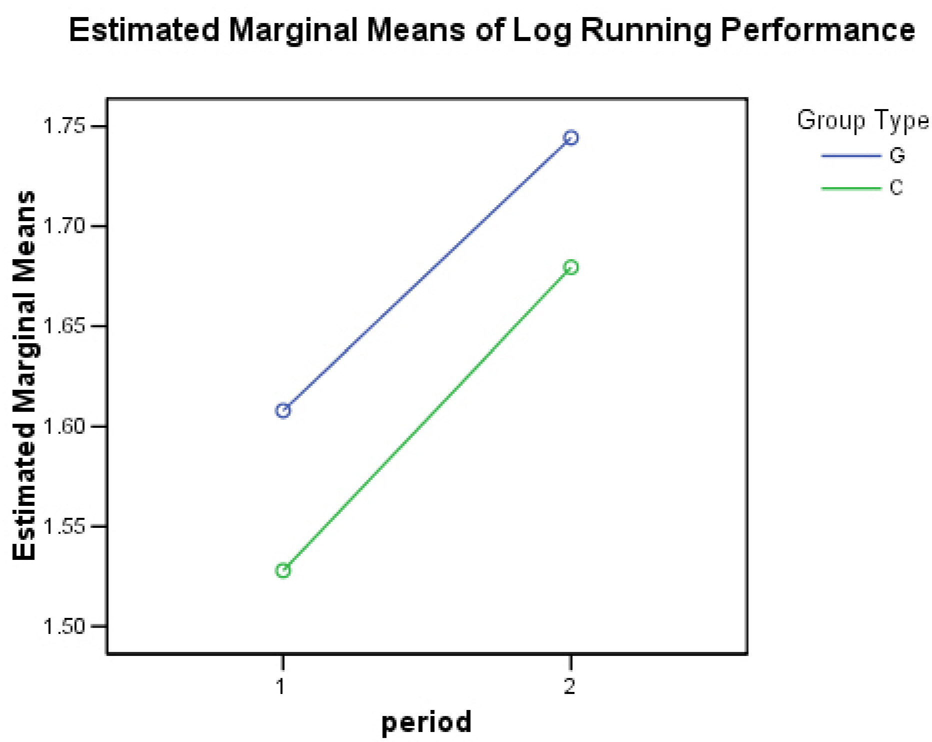
There was a statistically significant period effect (p value = <0.001), but no statistically significant group effect (p value = 0.885) or treatment effect (p value = 0.873).

Graph 4.3.6 shows that participants' pain levels did significantly improve between the two periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome, and the null hypothesis is therefore accepted for the outcome of the Numerical Rating Scale-101.

4.3.7 Running Performance (ITB Questionnaire):

Effect	**p value**
Period	<0.001
Treatment (group*period)	0.381
Group (order of treatments)	0.206

Table 4.3.7 p values for Running Performance (ITB Questionnaire) results



Graph 4.3.7 Group comparisons between Periods 1 and 2 for Log Running Performance

There was a statistically significant period effect (p = <0.001), but no statistically significant group effect (p value = 0.206) or treatment effect (p value = 0.381).

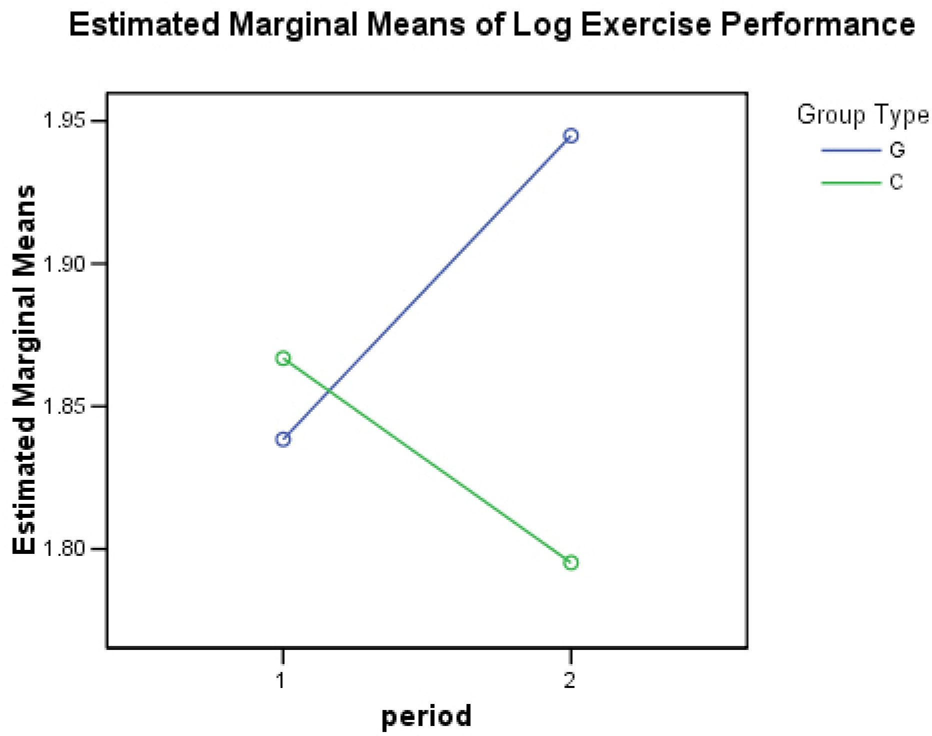
Graph 4.3.7 shows that participants' running performance did significantly improve over both periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome, and the null hypothesis is therefore accepted for the outcome of running performance.

Overall, Group "G" showed a better result for running performance compared to Group "C", but this difference was not statistically significant.

4.3.8 Exercise Performance (Daily Exercise Diary):

Effect	**p value**
Period	0.700
Treatment (group*period)	0.002
Group (order of treatments)	0.127

Table 4.3.8 p values for Daily Exercise Diary results



Graph 4.3.8 Group comparisons between Periods 1 and 2 for Log Exercise Performance

For exercise performance there was no statistically significant difference in period effect (p value = 0.700) or group effect (p value = 0.127), but the difference in treatment effect between the groups was significant (p value = 0.002).

There was a difference in exercise performance according to whether stretching or strengthening was done. Graph 4.3.8 shows that at each period, the group that was stretching had higher exercise performance scores than the group that was strengthening. Group "G", the group that performed the strengthening exercise in period 1 and then the stretching exercise in period 2 showed much improved results in exercise performance between periods 1 and 2. Group "C", which performed the reverse order of exercises, showed poorer exercise performance results at the end of period 2 compared to the end of period 1. Thus, stretching appeared easier to perform than strengthening for this particular outcome.

The null hypothesis is accepted for exercise performance, due to there being no statistically significant group or period effects (neither the difference in order, nor the duration that the exercises were performed, showed significant difference).

Chapter Five

<u>Discussion</u>

5.1. Introduction

In this chapter, the results of the objective, subjective, and performance findings are discussed. At the end of the chapter, a few comparisons are made between this study and other related studies.

5.2. Discussion of Results

5.2.1. The Objective Findings:

5.2.1.1 Noble's Compression Test.

Noble's Compression test was shown to have a statistically significant period effect (p value = 0.022), but no statistically significant treatment or group effects (see *Table 4.3*). Therefore, both groups showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them.

The null hypothesis is therefore accepted for Noble's Compression test, i.e. there is no difference between the two groups for the outcome of Noble's Compression Test. This is possibly because both the stretching and strengthening exercises

performed in both combinations were almost equally effective for the outcome of Noble’s Compression Test. (see *Graph 4.2.2*)
Although it was not statistically significant, it should be noted that overall, Group “G” appears to have done better for Noble’s test, with a best result of 93% negative by the last week, while Group “C” achieved a best result of 87% negative by the last week. A larger sample size may have produced a statistically significant difference.

The latest related studies in the literature (Fredericson *et al*, 2000) unfortunately do not indicate any results for Noble’s Compression Test for a comparison with the results of this study.

The improved results for Nobles’ Compression Test (by both groups) are consistent with improved ITB flexibility (Noble *et al,* 1982) in both groups, as confirmed below in 5.2.1.4.

5.2.1.2 Modified Ober’s Test.

For the Modified Ober’s test, the analysis of the data was unsuccessful, as no convergence was achieved on the GEE model. This was due to the fact that for period 1, all subjects except one had positive Ober’s tests, while for period 2, all subjects had negative tests. (see *Graph 4.2.1*)

This implies that with the Modified Ober’s test there was a period effect, but no treatment or group effects. We cannot comment on statistical significance as no tests of significance were possible.

Therefore, both groups showed improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them. The null hypothesis is therefore tentatively accepted for the

Modified Ober's test, i.e. there is no difference between the two groups for the outcome of the Modified Ober's Test. This is possibly because both the stretching and strengthening exercises were almost equally effective for the outcome of the Modified Ober's test (see *Graph 4.2.1*).

It should be noted that Group "G" showed a better overall improvement in Ober's test results from start to finish, with 100% of its participants improving. Group "C" showed improvement in 80% of its participants.

The latest related studies in the literature (Fredericson *et al*, 2000) unfortunately do not indicate any results for the Modified Ober's Test for a comparison with the results of this study.

The improved results for the Modified Ober's Test (by both groups) are consistent with improved ITB flexibility (Reid, 1992:424-429) in both groups, as confirmed below in 5.2.1.4.

5.2.1.3 Gluteus Medius Strength Test.

Gluteus Medius strength only showed a statistically significant period effect (p value = <0.001). There was no statistically significant difference in effect of the different treatments (treatment effect) or of the order of treatments (group effect), see *Table 4.3.1*. Both groups therefore showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them.

The null hypothesis is therefore accepted for the Gluteus Medius Strength Test i.e. there is no difference between the two groups for the outcome of Gluteus Medius Strength Test. This is possibly because both the stretching and strengthening exercises performed in both combinations proved to be almost equally effective for the outcome of the Gluteus Medius Strength Test. (see *Graphs 4.2.3 and 4.3.1*)

Even though statistically non-significant, Group "G" produced better overall results for gluteus medius strength, with a total improvement of 10 seconds, while Group "C" showed a total improvement of 9.5 seconds. A larger sample size may have produced a statistically significant difference.

The improvements gained in gluteus medius strength by both groups are consistent with the findings of Fredericson, *et al* (2000), who concluded that improvement in hip abductor strength parallels symptom improvement with successful gain in running performance, as confirmed below in 5.2.3.1.

5.2.1.4 Hip Adduction Angle.

Analysis of Hip Adduction Angle included the baseline measurement of hip adduction angle as a covariate to control for significant baseline differences found between the groups. There was a statistically significant period effect (p value = <0.001), and only a marginally non-significant group effect (p value = 0.098). The treatment effect was also found to be statistically non-significant (p value = 0.150).

There were thus no differences in effectiveness between the treatments or the order in which they were applied. The null hypothesis is therefore accepted for Hip Adduction Angle, i.e. there is no difference between the two groups for the outcome of Hip Adduction Angle. This is possibly because both the stretching and strengthening exercises performed in both combinations were almost equally effective for the outcome of Hip Adduction Angle. (see *Graphs 4.2.4 and 4.3.2*)

Although statistically non-significant, Group "C" produced better results in hip adduction angle, with a total improvement of 12 degrees, while Group "G" showed a total improvement of 10 degrees. A larger sample size may have produced a statistically significant difference.

The improvements gained in hip adduction angle by both groups are consistent with the findings of the study by Bandy and Reese (2003), from which it was concluded that an improvement in hip adduction angle is a reliable indicator of an improvement in ITB flexibility.

5.2.1.5 Hip Abduction Angle.

There was a statistically significant period effect (p value = <0.001), but no statistically significant differences in group or treatment effect between the groups (see *Table 4.3.3*). Graphs 4.2.5 and 4.3.3 therefore indicate that both groups showed significant improvement from both periods, regardless of which of the two treatments they had received, or the order in which they had received them. The null hypothesis is therefore accepted for Hip Abduction Angle, i.e. there is no difference between the two groups for the outcome of Hip Abduction Angle.

This test was included merely out of interest, to see whether a possible relationship may exist between hip abductor strength or hip abductor flexibility, and hip abduction angle, similar to the relationship that exists between hip adduction angle and ITB flexibility (Bandy and Reese, 2003).

Though statistically non-significant, the results have shown that the stretching exercises had produced better improvements in hip abduction angle than the strengthening exercises for both periods. This is consistent with one of the known effects of flexibility training: that improving a prime mover's flexibility - in this case, the gluteus medius - may improve the range that it can move its joint - in this case, abduction of the hip (Arnheim and Prentice, 1993:63). It may therefore be worthy of further investigation, whether hip abduction angle may be a valid indicator of gluteus medius flexibility.

It was expected that the strengthening exercises may have produced greater hip abduction angle results (i.e. to strengthen a prime mover would improve its movement of its joint). It is however known, as explained by (Arnheim and Prentice, 1993:63), that while a joint's movement is strengthened, it is not necessarily increased, and that increases in muscle strength are generally accompanied by decreased flexibility.

Although statistically non-significant, overall, Group "C" produced better results in hip abduction angle with a total improvement of 25 degrees, compared to a total of 20 degrees for Group "G".

5.2.1.6 Point Tenderness (Algometer readings).

There was a statistically significant period effect (p value = <0.001), and a marginally statistically significant treatment effect (p value = 0.049) in favour of the strengthening exercises (see *Table 4.3.4*).

Graphs 4.3.4 and 4.2.5 showed that from period 1, Group "G" (performing the strengthening exercises) had better point tenderness results compared to Group "C" (performing the stretches). From period 2, Group "C" (performing the strengthening exercises) showed better point tenderness results than Group "G" (performing the stretches). Therefore, the strengthening exercises produced better improvements in point tenderness in both periods, compared to the stretches, and these differences in period and treatment effects were statistically significant.

This was probably due to the stretching exercises that, while being performed, put the already tight ITB under further tension, thereby causing a mild exacerbation of the low-grade inflammation of chronic ITBS, present at the distal attachment of the band. This may have caused the increased point tenderness, as observed in our participants who ended the study with stretching. The inflammation is, after all, due to excessive tension of the band, causing it to rub against the lateral femoral epicondyle. (Nemeth *et al*, 1996; Nishimura *et al*, 1997)

The stretching exercises, which put the already tight ITB under further tension while they are performed, may also irritate the already strained distal insertional fibres of the tight band, and thereby exacerbate the low-grade inflammation present at the distal attachment of the ITB, causing an increase in point tenderness.

Even though there was a statistically significant difference in treatment effect favouring strengthening, on the outcome of point tenderness, there was no statistically significant difference in group effect (the order in which the treatments were received) and there was no statistically significant difference in the groups' point tenderness results between the end of period 1 and the end of period 2. The null hypothesis is therefore accepted for Point Tenderness, i.e. there is no difference between the two groups for the outcome of Point Tenderness.

Although statistically non-significant, overall, Group "C" produced better results for Point Tenderness than Group "G". A larger sample size may have produced a statistically significant difference.

5.2.2. The Subjective Findings:

5.2.2.1 Short-form McGill Pain Questionnaire.

There was a statistically significant period effect (p value = <0.001), but no statistically significant group or treatment effect (see *Table 4.3.5*). There was therefore no significant difference in McGill pain scores between Group "G" and Group "C", for whichever of the two treatments they had received, or whatever the order they had received the treatments. Participants' pain levels did significantly improve between the two periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome.

The null hypothesis is therefore accepted for this outcome, i.e. there is no difference between the two groups for the outcome of the Short-form McGill Pain Questionnaire. This is possibly because both the stretching and strengthening exercises performed in both combinations were almost equally effective for this outcome. (see *Graphs 4.2.7 and 4.3.5*)

The improved scores for the Short-form Mcgill Pain Questionnaire for both groups are consistent with the findings of Fredericson, *et al* (2000); Fredericson *et al* (2002). They confirmed symptom improvement from stretching and strengthening exercises for the ITB and Gluteus Medius.

Overall, although statistically non-significant, Group "C" produced better results than Group "G" for the Short-from McGill Pain Questionnaire. A larger sample size may have produced a statistically significant difference.

5.2.2.2 Numerical Rating Scale-101 (NRS-101).

There was a statistically significant period effect (p value = <0.001), but no statistically significant group or treatment effect. (see *Table 4.3.6*)

Participants' pain levels did significantly improve between the two periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome. The null hypothesis is therefore accepted for this outcome, i.e. there is no difference between the two groups for the outcome of the Numerical Rating Scale-101. This is possibly because both the stretching and strengthening exercises performed in both combinations were almost equally effective for this outcome. (see *Graphs 4.2.8 and 4.3.6*)

The improved scores for the Numerical Rating Scale-101 for both groups are consistent with the findings of Fredericson, *et al* (2000); Fredericson *et al* (2002). They confirmed symptom improvement from stretching and strengthening exercises for the ITB and Gluteus Medius.

Overall, both groups showed the same total improvement in pain levels, as rated by the NRS-101. A larger sample size may have produced a statistically significant difference.

5.2.3. The Performance Findings:

5.2.3.1 Running Performance.

There was a statistically significant period effect (p = <0.001), but no statistically significant group or treatment effect. (see *Table 4.3.7*)

Participants' running performance did significantly improve over both periods for both groups, indicating that both of the treatments, regardless of their order, produced significant effect for this outcome. The null hypothesis is therefore accepted for running performance, i.e. there is no difference between the two groups for the outcome of Running Performance. This is possibly because both the stretching and strengthening exercises performed in both combinations were almost equally effective for this outcome. (see *Graphs 4.2.9 and 4.3.7*)

The improvements gained in running performance by both groups are consistent with the findings of Fredericson, *et al* (2000), who concluded that improvement in hip abductor strength (as confirmed above in 5.2.1.3) parallels symptom improvement with successful gain in running performance.

It should be noted, although statistically non-significant, that overall, Group "G" produced better running performance results than Group "C". A larger sample size may have produced a statistically significant difference.

5.2.3.2 Exercise Performance.

For exercise performance there was no statistically significant difference in period effect or group effect, but the difference in treatment effect between the groups was significant (p value = 0.002). (see *Table 4.3.8*).

There was a difference in exercise performance according to whether stretching or strengthening was done. Graphs 4.2.10 and 4.3.8 show that at each period, the group that was stretching had higher exercise performance scores than the group that was strengthening. Group "G", the group that performed the strengthening exercise in period 1 and then the stretching exercise in period 2 showed much improved results in exercise performance between periods 1 and 2. Group "C", which performed the reverse order of exercises, showed poorer exercise performance results at the end of period 2 compared to the end of period 1. Thus stretching appeared easier to perform than strengthening for this particular outcome, and was therefore performed more successfully. It may therefore be advisable, to follow the order of strengthening followed by stretching as for Group "G", which showed a much better overall exercise performance result than Group "C". The reverse combination followed by Group "C" showed that they struggled to perform the strengthening exercises successfully after performing the stretching exercises.

This differs from the treatment protocol outlined by Fredericson, Guillet, and DeBenedicitis, *et al* (2000), in which it was prescribed that stretching exercises be performed before strengthening exercises.

The null hypothesis is accepted for exercise performance, due to there being no statistically significant group or period effects, i.e. neither the difference in order, nor the duration that the exercises were performed, produced a significant difference between the two groups.

5.3. Comparison with other Research

In the study by Fredericson, Guillet and DeBenedictis, *et al* (2000), an aggressive, comprehensive treatment plan for ITBS was outlined. Aside for the numerous treatment modalities and techniques involved, stretching exercises were incorporated in the subacute phase, and strengthening of the hip abductors was introduced thereafter, in the recovery phase. The stretching and strengthening exercises employed in the study were proven highly effective, and the same exercises were therefore used in our study.

Fredericson, Cookingham and Chaudhari *et al,* (2000), undertook another study to examine the hip abductor strength in long-distance runners with ITBS, comparing their injured limb strength to their uninjured limb, and with unaffected runners; and to determine whether correction of the strength deficits in the hip abductors of the affected runners through a rehabilitation program correlated with a successful return to running.

Their study involved a 6 week rehabilitation program directed at strengthening the weak hip abductiors. 30 participants were selected – 14 women 16 men – with both ITBS and weak hip abductors.

It was found that pre-rehabilitation group differences in hip abductor strength were statistically significant at the $p<0.05$ level. Post-rehabilitation, females demonstrated a 34.9% increase in hip abductor torque and males, a 51.4% increase. 92% of the participants returned to running pain free at the end of the study, and at a 6 month follow-up, there were no reports of recurrence.

It was concluded that long distance runners with ITBS have weaker hip abductor strength in the affected leg compared with their unaffected leg and with unaffected runners. Also, that symptom improvement with successful return to running parallels improvement in hip abductor strength.

Both the above studies have yielded results showing statistically convincing improvements in patients with ITBS by incorporating hip abductor strengthening as part of a comprehensive treatment algorithm, and even when it was made to be the sole focus of the treatment.

In this study, we have included many similar factors as these latest studies involving hip abductor strengthening in treating ITBS. We have used the same exercises, the same sample size (30 participants), and the same treatment period (6 weeks). But we have taken the research further, with the intention of finding a possible difference in effectiveness between stretching and strengthening performed in different order, by using a two-treatment, two-period cross-over trial design.

Chapter Six

<u>Recommendations and Conclusions</u>

6.1. Conclusions:

The study consisted of 30 participants divided randomly and equally into two groups. Group "G" consisted of those who received strengthening exercises in the first period of the study, and stretching exercises in the second period of the study, while Group "C" consisted of those who received stretching exercises in the first period of the study, followed by strengthening exercises in the second period. All participants underwent an extensive medical history, physical and orthopaedic examinations, from which their diagnosis of chronic iliotibial band syndrome was made.

All participants received weekly treatment over 6 weeks, with both periods of the treatment being 3 weeks in duration for both groups.

The results of the study suggest that for the majority of the outcomes, there was no statistically significant difference between the stretching and strengthening exercises, or the order in which the exercises were done (inter-group analysis). The period effect (duration) was statistically significant for most outcomes, meaning that there was a significant improvement from the first and the second periods for both groups, regardless of order of the exercises (intra-group analysis). Ultimately, having done both exercises was significantly better than having done one exercise, regardless of which exercise that was.

Although the results have not shown statistical significance, the following should be noted:

Group “G” showed better results for the Modified Ober’s test, Noble’s Compression test, and more importantly the Gluteus Medius Strength test, Running Performance and Exercise Performance.

Group “C” had better results for Hip Adduction Angle, Hip Abduction Angle, Point Tenderness, and the Short-form McGill Pain Questionnaire. The Groups were tied for the Numerical Rating Scale-101.

Group “G” therefore showed better improvement in the orthopaedic tests specific for ITBS (i.e. Modified Ober’s Test and Noble’s Compression Test), and better improvement for the outcomes emphasised in this study (i.e. Gluteus Medius Strength Test, Running Performance, and Exercise Performance).

Therefore, although statistically non-significant, Group “G” produced better overall results than Group “C”, and thus, it appears that the combination of strengthening followed by stretching, may be more effective than the combination of stretching followed by strengthening, in the treatment of chronic ITBS in long distance runners. Further investigation involving a larger sample size and a more homogenous group of participants in terms of their grade of ITBS, their age and their running calibre may produce statistically significant results.

Ultimately, the performance of both exercises, regardless of the order performed, is significantly more effective than performing only one of the exercises, regardless of which of the exercises it is.

6.2. Recommendations:

For future studies, the following recommendations may be made:

1. A digital manual muscle tester should be used to obtain a more accurate measurement of hip abductor strength. (Fredericson *et al,* 2002) According to the literature, the Nicholas Manual Muscle Tester is most commonly used for this purpose (NISMAT, 2000). It was unfortunately not possible to obtain this equipment due to the study's limited budget.
2. A more homogenous group of runners in terms of their grade of ITBS, their age and their running calibre should be selected in future studies, so that the effects of the intervention can be analysed from more uniform baseline data. Trends in the results may become more apparent from more uniform baseline data.
3. A larger sample size may improve the statistical significance of some of the results.
4. A long-term follow-up examination (1 month after the study) may prove valuable in showing the long-term effect of the treatment, as was done in the study by Fredericson, Cookingham and Chaudhari *et al*, (2000).
5. The effect of sacro-iliac joint manipulation on hip abductor strength and ITBS may prove worthwhile. Terblanche (2004) investigated the effect of sacroiliac joint manipulation on hip muscle strength. The results showed a significant short-term increase in hip abductor muscle strength after sacroiliac joint manipulation. Further research may therefore find sacroiliac joint manipulation to be an effective addition to strengthening and stretching exercises in maintaining or improving hip abductor strength in long distance runners suffering with chronic ITBS, thereby improving recovery.

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Addendum A:

Patient Information Letter :

Dear Patient,

Title of research project:

The effectiveness of Gluteus Medius and Iliotibial Band stretching, versus strengthening, in the rehabilitation of Iliotibial Band Syndrome in long distance runners.

Principal Investigators:

AK. Gangat. (Chiropractic Intern) Tel: 204-2205 / 083 - 471 2167

Dr. Aadil Docrat. (MTech. Chiro) – Research Supervisor. Tel: 204-2589.

Introduction:

Thank you for your interest in participating in this chiropractic research into the treatment of Iliotibial Band Syndrome (ITBS), at the Chiropractic Day Clinic of the Durban Institute of Technology. ITB Syndrome refers to the condition in which a burning pain occurs on the outer side of the knee due to an irritation of the ITB, which becomes inflamed. This injury most commonly occurs in the sports of long distance running and cycling. This letter serves to inform of you what the research procedure involves.

Purpose of the Study:

This research project forms part of the requirement for the completion of my Master's Degree in Technology: Chiropractic. I, AK. Gangat, will be conducting the study under the supervision of Dr. Aadil Docrat.

Procedure:

At your first visit, a history of your problem will be taken. You will be given a basic physical examination, as well as an examination of your hips and knees. From the results of these examinations, it will be decided whether or not you qualify as a candidate for the research. If you do meet the requirements for the research, you will receive your first treatment right away, and you will be required to attend a "follow-up" visit once a week for the next 5 weeks.

Your first treatment will involve performing a set of exercises for a few specific buttock and thigh muscles. You will be shown exactly how to do the exercises correctly, and you will be required to do the exercises at home on a daily basis. A pamphlet containing the exercises will be given to you, as well as an exercise diary to keep you on track, and a questionnaire to monitor your progress. You will be shown how to fill these in.

The "follow-up" visits once a week for 5 weeks will involve a short re-examination of your ITB, and the performance of the same exercises with my assistance and supervision. You will be required to hand in your week's exercise diary and questionnaire at each follow-up visit, for data collection.

Risks/Discomforts:

This treatment may cause mild "tightness" and mild transient soreness of the Iliotibial Band and Gluteus Medius muscle.

Benefits:

This treatment may help to reduce the symptoms of Iliotibial Band Syndrome.

New Findings:

Latest research studies into the treatment of ITBS have involved strengthening of the Gluteus Medius muscle. This technique is included in this study.

Reason why you may be withdrawn from the study without your consent:

You may be excluded from the study for the following reasons:

- Failure to follow the instructions given to you by the researcher.
- Failure to perform the home exercises as outlined by the researcher.
- Failure to complete the “ITB Questionnaire” and “Daily Exercise Diary” as outlined by the researcher.
- Receiving any other form of treatment (including medication), during your participation in the study.
- Failure to attend your scheduled appointments.

Remuneration:

Participants will not receive any payment for their participation in this study, which is entirely voluntary. All treatment in this research is free.

Confidentiality:

All participant information will be kept strictly confidential, and will be used solely for the purpose of this research study.

Persons to contact for Questions or Problems:

Please feel free to direct any questions or queries that you may have to either myself, AK. Gangat, or Dr. Docrat, the research supervisor.

Thank you for participating.

AK. Gangat. (Chiropractic Intern).

Dr. Aadil Docrat. (MTech. Chiro) - Research Supervisor.

Addendum B:

Informed Consent Form:

Date: ________________

Title of research project:
The effectiveness of Gluteus Medius and Iliotibial Band stretching, versus strengthening, in the rehabilitation of Iliotibial Band Syndrome in long distance runners.

Name of Supervisor: Dr. Aadil Docrat. (Mtech. Chiro) (Tel: 204-2589)

Name of research student: AK. Gangat. (Tel: 204-2205 / 083-471 2167)

Name of Institution: Durban Institute of Technology.

Please circle the appropriate answer: **YES (Y) NO (N)**

1. Have you read the patient information letter?
   (Y) (N)
2. Have you had an opportunity to ask questions regarding this study?
   (Y) (N)
3. Have you received satisfactory answers to your questions?
   (Y) (N)
4. Have you had an opportunity to discuss the study?
   (Y) (N)
5. Have you received enough information about this study?
   (Y) (N)

6. Do you understand the implications of your involvement in this study?
   (Y) (N)
7. Do you understand that you are free to withdraw from this study:
   - at any time,
   - without having to give a reason for withdrawing, and
   - without affecting your future health care

   (Y) (N)
8. Do you agree to voluntarily participate in this study?
   (Y) (N)
9. Who have you spoken to?____________________________________

Please ensure that the researcher completes each section with you.
If you have answered NO to any of the above, please obtain the information before signing.

<u>Please print in block letters:</u>

Patient/Participant name: __________________ Signature: ________________

Witness name: ___________________________ Signature: ________________

Research Student name: __________________ Signature: ________________

Intern's Case History:

1. **Source of History:**
2. **Chief Complaint : (patient's own words):**
3. **Present Illness:**

	Complaint 1	Complaint 2
▸ Location		
▸ Onset : Initial:		
Recent:		
▸ Cause:		
▸ Duration		
▸ Frequency		
▸ Pain (Character)		
▸ Progression		
▸ Aggravating Factors		
▸ Relieving Factors		
▸ Associated S & S		
▸ Previous Occurrences		
▸ Past Treatment		
▸ **Outcome:**		

4. **Other Complaints:**

5. **Past Medical History:**

- General Health Status
- Childhood Illnesses
- Adult Illnesses
- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

6. Current health status and life-style:

- Allergies
- Immunizations
- Screening Tests incl. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

Addendum D: Physical Examination

Patient:__________________________________**File#:**____________**Date:**_______
_Student: **Signature:**

VITALS

Pulse rate			Respiratory rate	
Blood pressure	R	L	Medication if hypertensive:	
Temperature			Height	
Weight:	Any recent change Y/N	If Yes : how much gain/loss		Over what period

GENERAL EXAMINATION

General Impression	
Skin	
Jaundice	
Pallor	
Clubbing	
Cyanosis (Central/Peripheral)	
Oedema	
Lymph nodes - Head and neck	
- Axillary	
- Epitrochlear	
- Inguinal	
Pulses	
Urinalysis	

SYSTEM SPECIFIC EXAMINATION

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

COMMENTS

NEUROLOGICAL EXAMINATION: See regionals

Clinician: **Signature:**

Addendum E: Knee Regional Examination

Patient:______________________________ File:__________ Date:________
Intern:______________________________ Signature:______________________________
Clinician:______________________________ Signature:______________________________

- **OBSERVATION (**Standing, Seated and during gait cycle).

A. Anterior view
Genu Varum:____________________
Genu Valgum:____________________
Patellar position:____________________
Tibial Torsion:____________________
Skin:____________________
Swelling:____________________

B. Lateral view
Genu Recurvatum:____________________
Patella Alta:____________________
Patella Baja:____________________
Skin:____________________

C. Posterior view
Swelling:____________________
Skin:____________________

D. General
Movement symmetry:____________________
Structures symmetry:____________________

- **ACTIVE MOVEMENTS**

Flexion (0 - 135°)____________________
Extension (0 - 15°)____________________
Medial Rotation (20 - 30°)____________________
Lateral rotation (30 - 40°)____________________

- **PASSIVE MOVEMENTS**

Tissue approx____________________
Bone-bone____________________
Tissue stretch____________________
Tissue stretch____________________
Patellar movement____________________

- **RESISTED ISOMETRIC MOVEMENTS**

Knee: Flexion:____________________
Extension:____________________
Internal rotation:____________________
External rotation:____________________

Ankle: Plantarflexion____________________
Dorsiflexion____________________

- **LIGAMENTOUS ASSESSMENT**

One-Plane Medial Instability
Valgus stress (abduction)
Extended____________________
Resting Position____________________

One-Plane Lateral Instability
Varus stress (adduction)
Extended____________________
Resting Position____________________

One-Plane Anterior Instability
Lachman Test (0-30°)____________________
Anterior Drawer Sign ____________________

One-Plane Posterior Instability
Posterior "sag" Sign____________________
Posterior Drawer Test____________________

Anterolateral Rotatory Instability
Slocum Test____________________
Macintosh Test____________________

Anteromedial Rotatory Instability
Slocum Test____________________

Posterolateral Rotatory Instability
Jacob ____________________
Hughston's Drawer Sign____________________
Reverse pivot shift test____________________

Posteromedial Rotatory Instability
Hughston's Drawer Sign____________________

- **TESTS FOR MENISCUS INJURY**

McMurray_______________ Anderson med-lat grind_______________
"Bounce Home"_______________ Apley's_______________

- **PLICA TESTS**

Mediopatellar Plica _______________ Hughston's Plica_______________
Plica "Stutter" _______________

- **TESTS FOR SWELLING**

Brush/Stroke Test _______________ Patellar Tap Test_______________

- **TESTS FOR PATELLA FEMORAL PAIN SYNDROME**

Clarke's Sign _______________ Passive patella tilt test_______________
Waldron test_______________

- **OTHER TESTS**

Wilson's_______________ Quadriceps Contusion Test_______________
Fairbank's_______________ Leg Length Discrepancy_______________
Noble Compression_______________

- **JOINT PLAY**

Movement of the tibia on the femur P → A:__________ A → P:__________
Translation of the tibia on the femur M → L:__________ L → M:__________
Long axis distraction of the tibiofemoral joint
Inf, sup, lat, + med glide of the patella
Movement of the inf. tibiofibular joint A → P__________ P → A__________
Movement of the sup. tibiofibular joint A → P__________ P → A__________
Movement of the sup tibiofibular joint S → I__________ I → S__________

- **PALPATION**

Tenderness_______________ Swelling_______________
Joint line_______________ Nodules/exostoses_______________
Ligaments_______________ Muscles: thigh:_______________
Patella:_______________ Leg :_______________
Patella tendon:_______________ Popliteal artery:_______________
Bursae:_______________

- **REFLEXES AND CUTANEOUS DISTRIBUTION**

	R	L
Patellar Reflex (L3,L4)		
Medial Hamstring Reflex (L5,S1)		

- **DERMATOMES**

	R	L		R	L
L2			S1		
L3			S2		
L4			S3		
L5					

21/10/2002

Addendum F: Hip Regional Examination

Patient: ______________________ **File no:** __________ **Date:** ______

Intern / Resident: ______________________ Signature: ______________________

Clinician: ______________________ Signature: ______________________

Observation

- Gait: ______________________ • Posture: ______________________
- Weight-bearing symmetry: ______________________
- Balance and proprioception (Stork-standing test): ______________________
- Bony / soft tissue contours: Buttock contour ______________________
  - Hip flexion contracture ______________________
  - Lumbar lordosis ______________________
  - Scoliosis ______________________
- Skin: ______________________ • Swelling: ______________________
- Leg length inequality: ______________________

Palpation

- Anterior aspect:

Iliac crests ______________________

Greater trochanter ______________________

Pubic symphysis and tubercle ______________________

Femoral head ______________________

Femoral Δ - femoral artery ______________________

- lymph nodes ______________________

ASIS's ______________________

Inguinal ligament ______________________

Inguinal hernia ______________________

Muscles - Quadriceps ______________________

- Adductors ______________________
- Abductors ______________________
- Psoas ______________________

- Posterior aspect:

Iliac crests posteriorly ______________________

Ischial tuberosity ______________________

Muscles - Piriformis ______________________

- Gluteals ______________________
- Hamstrings ______________________

PSIS's ______________________

Sciatic notch ______________________

SI joints ______________________

Lumbar Spine ______________________

Sacrum + coccyx ______________________

Active Movements (note ROM and pain)

Flexion (110-120°) ______________________

Extension (10-15°) ______________________

Adduction (30°) ______________________

Abduction (30-50°) ______________________

Medial rotation (30-40°) ______________________

Lateral rotation (40-60°) ______________________

Passive Movements (note end-feel, ROM and pain)

Flexion (tissue stretch or approximation) ____________________
Extension (tissue stretch) ____________________
Adduction (tissue stretch or approximation) ____________________
Abduction (tissue stretch) ____________________
Medial rotation (tissue stretch) ____________________
Lateral rotation (tissue stretch) ____________________

Resisted Isometric Movements (note strength and pain)

Flexion ____________________
Extension ____________________
Adduction ____________________
Abduction ____________________
Medial rotation ____________________
Lateral rotation ____________________
Knee flexion ____________________
Knee extension ____________________

Joint Play Movements

Caudal glide (long axis traction) ____________________
Compression ____________________
Lateral distraction ____________________
Quadrant (scouring) test ____________________

Special Tests

Patrick's FABER Test ____________________
Trendelenberg Test ____________________
Craig's Test ____________________
Leg Length: Actual __________ (L) __________ (R) Apparent __________ (L) __________ (R)
Sign of the Buttock ____________________
Thomas Test (hip flexion contracture) ____________________
Rectus Femoris Contracture Test ____________________
Ely's Test (rectus femoris hypertonicity) ____________________
Ober's Test (ITB contracture) ____________________
Noble Compression Test (ITB Friction Syndrome) ____________________
Piriformis Test ____________________
Hamstrings: Hamstring Contracture Test ____________________
90°-90° SLR Test ____________________
Tripod Test ____________________

Radiological Examination:

____
____
____
____

Diagnosis: ____________________
____
____

Management Plan: ____________________
____
____
____
____
____

Addendum G: Numerical Rating Scale-101 Questionnaire

Numerical Rating Scale - 101 Questionnaire

Date:__________ **File no:**__________ **Visit no:**________

Patient name:____

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **when it is at its worst**. A zero (0) would mean "no pain at all", and one hundred (100) would mean "pain as bad as it could be".

Please write only **one** number.

____

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **when it is at its least**. A zero (0) would mean "no pain at all" and one hundred (100) would mean "pain as bad as it could be".

Please write only **one** number.

____

Addendum H:

Short-form McGill Pain Questionnaire (SF-MPQ)

Ronald Melzack (1984)

Date:____________ File no.:_______________ Visit no:____

Patient name:____

	NONE 0	MILD 1	MODERATE 2	SEVERE 3
THROBBING				
SHOOTING				
STABBING				
SHARP				
CRAMPING				
GNAWING				
HOT-BURNING				
ACHING				
HEAVY				
TENDER				
SPLITTING				
TIRING-EXHAUSTING				
SICKENING				
FEARFUL				
PUNISHING-CRUEL				

Addendum I:

Numerical Performance Rating Scale – "Running with ITBS" Questionnaire

Please indicate on the line below, the number between 0 and 100 that best describes your running performance **now,** compared to your running performance **just before your injury.** A zero (0) would mean "no change at all", and a hundred (100) would mean that you are now running just as well as you did before the injury.

____

Addendum J:

ITB Questionnaire

	Initial	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6

1. Km run per week :

- ❑ 0 – 9km
- ❑ 10 – 19km
- ❑ 20 – 29km
- ❑ 30 – 39km
- ❑ 40 – 49km
- ❑ 50 – 59km
- ❑ 60 – 69km
- ❑ 70km + (please specify)

2. Distance run per session:

- ❑ 0 – 5km
- ❑ 6 – 10km
- ❑ 11 – 15km
- ❑ 16 – 20km
- ❑ 21 – 25km
- ❑ 26 – 30km
- ❑ 30km + (please specify)

3. Distance run at onset of pain:

- ❑ 0 – 5km
- ❑ 6 – 10km
- ❑ 11 – 15km
- ❑ 16 – 20km
- ❑ 21 – 25km
- ❑ 26 – 30km
- ❑ 30km + (please specify)
- ❑ no pain experienced.

4. Occurrence of pain:

- ❑ No pain experienced before, during, or after running.
- ❑ Pain comes on after running, but does not restrict distance or speed.
- ❑ Pain comes on during a run, but does not restrict distance or speed.
- ❑ Pain comes on during a run and restricts distance or speed.
- ❑ Pain is so severe that it prevents running.

5. Pain Intensity While Running:

- ❑ No pain experienced while running.
- ❑ Pain while running was very mild.
- ❑ Pain while running was moderate.
- ❑ Pain while running was fairly severe.
- ❑ Pain while running was very severe.

Addendum K:

<u>Daily Exercise Diary:</u>

1. The exercise was too painful to perform.
2. The exercise was painful, but manageable.
3. The exercise was mildly uncomfortable.
4. The exercise was completely comfortable to perform.

Please enter your response (numbers ***1*** to ***4***) in the blocks below:

	Week 1:	Week2:	Week 3:	Week 4:	Week 5:	Week 6:
Day 1	أ	أ	أ	أ	أ	أ
Day 2	أ	أ	أ	أ	أ	أ
Day 3	أ	أ	أ	أ	أ	أ
Day 4	أ	أ	أ	أ	أ	أ
Day 5	أ	أ	أ	أ	أ	أ
Day 6	أ	أ	أ	أ	أ	أ
Day 7	أ	أ	أ	أ	أ	أ

Addendum L:

Results Sheet:

Key:

Modified Ober's test = O

Noble's Compression test = N

Gluteus Medius Strength test = S

ITB Flexibilty (Inclinometer reading) = I

Hip Abduction ROM (Inclinometer reading) = A

Point Tenderness (Algometer reading) = P

	Initial	***Week 1***	***Week 2***	***Week 3***	***Week 4***	***Week 5***	***Week 6***
O =							
N =							
S =							
I =							
A =							
P =							