A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area.

By

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I, Kelly Michelle Sutherland, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

I WOULD LIKE TO DEDICATE THIS STUDY TO MY MOM AND DAD, DIANE AND ANDREW SUTHERLAND. MOM AND DAD THANK YOU FOR YOUR UNCONDITIONAL LOVE, UNFAILING PATIENCE AND UNBELIEVABLE SUPPORT AND ENCOURAGEMENT THROUGHOUT MY LIFE AND ESPECIALLY DURING MY DEGREE. YOU'RE AMAZING PARENTS AND IT IS AN HONOUR TO BE YOUR DAUGHTER.

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Abstract

Introduction:

Swimming is one of the most popular participation sports [1] as people are drawn to swimming for leisure, cardiovascular workouts, or competition [2] . As a result, the sport of swimming has improved greatly over the past 20 years [3] .

Objectives:

The aim of this study was to determine a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa; as well as to determine whether any relationships exist between swimming injuries sustained in this study and the risk factors identified in other studies, and to compare the results with international data.

Therefore; for the purpose of this study, the following information was gathered in order to build up an injury profile:

- Demographics of competitive swimmers in South Africa,
- The participants swimming history,
- The presence of any past or current injuries and
- Factors associated with current and previous injuries were also investigated.

Methods:

This study was a prospective, cross-sectional, questionnaire based study, investigating the profile of musculoskeletal injuries in 101 competitive swimmers in the greater Durban area.

The data was collected by means of a self-administrated questionnaire, which was completed by the participants, under the supervision of the researcher, parents or coach.

The study was limited to competitive swimmers residing in the greater Durban area. Participants were required to be between 10 and 30 years of age, and compete in a minimum of either three minor galas, one National gala, one International event or a combination of the above, during the season in which the research was conducted.

Results:

The overall prevalence of ever sustaining an injury due to swimming was relatively high (53.5%). The shoulder was the site where current injuries were most likely to occur followed by the lower back and knee. The factors associated with injury were previous injury due to another form of exercise or sport ($p= 0.002$), decreased rest periods ($p=0.001$), increased duration ($p<0.001$) and increased number of sessions swum per week ($p<0.001$).

The findings of the study concurred with literature with respect to the sustaining of an injury related to swimming. However with respect to the current site on injury the research findings differed with respect to the norm report which is that of the shoulder followed by the knee. The results with respect to the factors associated with injury, where not consistent with the literature indicating that there may be local factors that influence injuries. This warrants further investigation with due consideration to the recommendations from this study.

Keywords: swimming; injuries; quantitative profile

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Definitions

- **Backstroke:**

In Backstroke the swimmer is in the supine position in the water, their arms move in an alternating motion over their head and the legs perform a *flutter kick* (Shamus and Shamus, 2001).

- **Bands:**

This refers to a piece of swimming equipment. In the shape of a rubber ring that is secured around the ankles in order to increase lower body drag in an attempt to increase upper body strength.

- **Beta Coefficient:**

This is the beta coefficient from the logistic regression. The exponent of this is the odds ratio, thus this is the log of the odds ratio (Esterhuizen, 2007).

- **Beat:**

Beat is defined as the coordinated rhythmical movement between the upper and lower limbs and/ or the coordination between either the upper or the lower limbs order to obtain optimal swimming technique.

- **Breaststroke:**

Breaststroke is described as a bilateral and symmetrical movement in which the arms are required to move simultaneously in a horizontal plane. The bilateral movement of the arms is alternated by the bilateral leg movement, also referred to as the Breaststroke or *Whip Kick* (Shamus and Shamus, 2001; Rodeo,1999).

- **Butterfly:**

The butterfly stroke is described as a bilateral symmetrical overhead motion of the arms, combined with a simultaneous bilateral symmetrical undulating motion of the legs, referred to as the *Dolphin Kick* (Shamus and Shamus, 2001).

- **Frictional Drag:**

Frictional drag is the friction produced between the swimmers body and the water molecules. Surface smoothness plays an important role in frictional drag (Maglischo, 1982).

- **Form Drag:**

Form drag is defined as the resistance exerted on the body depending on the bodies position as it moves in the water (Shamus and Shamus, 2001).

- **Freestyle (Crawl):**

Freestyle is described as an alternating movement of the arms over the head with a bilateral alternating kick. The kick is better known as the *Flutter kick* (Shamus and Shamus, 2001).

- **Incidence:**

Incidence is defined as the rate at which healthy people develop a new symptom or disease over a specific period of time (Borenstein et al, 1995).

- **Mean:**

The average of numbers (n) computed by adding some function of the numbers and dividing by some function of n (Esterhuizen, 2007).

- **Mode:**

The mode is the most frequent value of a random variable (Esterhuizen, 2007).

- **Prevalence:**

Prevalence is defined as a measure of the number of people in a given population that have a symptom or disease at a particular time (Borenstein et al, 1995).

- **Participant:**

For the purpose of this study the terms 'patient' and 'participant' are utilised interchangeably.

- **The Profile of Musculoskeletal Injuries:**

For the purpose of this study the profile of musculoskeletal injuries is defined as the identification of injuries as well as the context of the injuries (demographics, risk factors, the prevalence and type of injuries).

- **Pull Buoy:**

A pull buoy is a flotation device that is placed between the legs while the swimmer is only able to pull with their arms (Jones, 1999).

- **Sculling:**

Sculling is a term used to describe the movement of the hand in the water. The hand is placed at an oblique angle to the direction in which it is travelling. Thus creating a forward propulsion of the body through the water (Shamus and Shamus, 2001).

- **Swimming:**

Swimming can be defined as the act of moving through the water by using the arms and legs. Swimming is a popular form of recreation, an important international sport, and a healthy exercise (Van Rossen, 1991). Swimming is a non-contact and non- weight bearing sport however injuries are still common (Rodeo, 1999). For the purpose of this study swimming was limited to pool swimming.

- **Taper:**

A taper is a period of decreased training before an athletic event to improve mental and physical readiness for competition (Ousley-Pahnke, 2001).

- **Wave Drag:**

Wave drag is described as the increase of resistance in the water due to the wavelike motion or turbulence created when the swimmer is swimming in the pool (Shamus and Shamus, 2001).

Abbreviations

- **B -** Beta Coefficient
- **CI -** Confidence Interval
- **CSIQ -** The Competitive Swimmers Injury Questionnaire
- **df -** Degrees of Freedom
- **GIQ -** The Gymnastics Injury Questionnaire
- **KZN -** KwaZulu Natal
- **n -** Sample Size
- **OR -** Odds Ratio
- **p value -** Probability value (if <0.05 then it is statistically significant)
- **Std. dev -** Standard Deviation
- **SE -** Standard Error
- **Wald -** This is the test statistic from the Wald chi square test from which the p value in the logistic regression is generated.

Chapter 1

Introduction to the study

1.1 Introduction

This chapter deals with explaining the rationale behind this study, and includes the aims, objectives, hypotheses and limitations of the study.

1.1.1 Background of swimming

Swimming is one of the most popular participation sports (Shamus and Shamus, 2001) as people are drawn to swimming for leisure, cardiovascular workouts, or to compete in swimming (Kammer, S; Young, C.C. and Niedfeldt, M.W., 1999). As a result the sport of swimming has improved greatly over the past 20 years (Johnson, J.E; Sim, F.H. and Scott, S.G. 1987).

Most competitive swimmers begin their careers as early as 7 years of age (Kammer, *et al.*, 1999). Retrospective studies show that from this early age they train all year round and belong to several different swimming teams (Kammer, *et al.*, 1999). Thus competitive swimmers have an intense training regime, with the elite swimmers swimming up to 11 two-hour sessions per week (Kammer, *et al.*, 1999), with an average swimming distance of 10 000 to 20 000 metres per day (Watkins, 1996). In addition to the distance in the water, the majority of competitive swimmers also follow a weight-training programme, which consists of three 30 to 50 minute sessions per week in the gym (Kammer, *et al.*, 1999). Fu and Stone (1994) stated that this weight training or 'dry land training' is needed to build their strength and endurance to cope with long distance swimming training.

Competitive swimmers complete all this training in order to be able to compete in a number of major and minor competitions throughout the year, as a swimmers success is based on their performance at these competitions. In

addition, studies show that the success attained by swimmers is due to their strength and endurance from the months of training (Kammer, *et al.*, 1999), with the ultimate goal of competitive swimmers therefore being to achieve maximum performance. According to Fu and Stone (1994) this can only be achieved by proper athlete care and development, together with training programmes that have a main focus on injury prevention (Kammer, *et al.*, 1999). Thus performance and hence development need to be directed at the four phases that are found in each stroke, the 'reach' or 'entry', 'catch', 'pull' and 'recovery' phase (Fu and Stone, 1994).

This is particularly pertinent as swimming is a unique sport were athletes are suspended in an unnatural environment (Fu and stone, 1994) where there are no firm surfaces from which they are able to propel themselves. To add to this there are requirements to use specific actions to breathe and water provides a degree of resistance to the swimmers movement (Watkins, 1996). Swimming also concentrates predominantly on upper body strength with the lower part of the body and legs being used mainly in the swimmers kick and in their starts and turns (Fu and Stone, 1994).

Competitive swimmers can be classified according to the stroke they swim, namely, Butterfly, Backstroke, Breaststroke or Freestyle (Crawl) or Individual Medley (IM), which is a combination of all four strokes; and the distance they swim, thus classifying them as Sprinters, Middle distance or Long distance swimmers.

To understand the profile of musculoskeletal injuries in competitive Swimmers in the greater Durban area, this study focused on investigating the factors that previous studies suggested may predispose swimmers to injuries. Recommendations are made with respect to prevention or intervention strategies with regards to stroke correction and other factors that impact on injuries. However, the success of prevention or intervention strategies is outside the scope of this study.

1.1.2 Aim of the study

The aim of this study was to determine a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa; and to compare it with the international data that is available.

Therefore; for the purpose of this study, the following information was gathered in order to build up an injury profile:

- Demographics of competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa,
- The participants swimming history,
- Their record of any past or current injuries and
- Factors associated with previous and current injuries were also investigated.

1.2 Objectives and Hypotheses

1.2.1 The First objective was to describe and summarize the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area, KwaZulu-Natal, South Africa with respect to questionnaire responses outlining the profile of musculoskeletal injuries. Data collection was with respect to the following factors:

- Participants demographics including age, gender, ethnic group, and type of swimmer.
- Swimming history including number of years swimming experience, number of hours of training per week, number of swimming sessions attended per week, distance swum per week, gala information and level of competition.
- Factors related to injuries:
  - Location of current and previous injuries,
  - Length of time for which the current and previous injuries had been present,

- Effect of current and previous injuries on swimming training and competitions,
- Length of time for which swimming was prevented as a result of these injuries,
- Mechanism of current injury,
- Severity of current injury and
- Treatment received for current or past injuries.
- Eating habits and supplementation,
- Additional recreational and/ or competitive activities and
- Regular maintenance treatment and/ or stroke correction to improve performance.

The hypothesis was that the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area will differ from those of other countries.

1.2.2 The Second objective was to identify the association between context factors (definition of the profile of musculoskeletal injuries pg xxii) and the report of the injuries.

The hypothesis indicated that there would be no relationship between the context factors (demographics, risk factors, prevalence and type of injuries) in the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area.

1.3 Rationale behind the study

When assessing the profile of musculoskeletal injuries in competitive swimmers there are a number of parameters that must be considered. In a study by Rovere and Nichols (1985), it was found that a significant relationship between knee pain and the increase in the swimmers age, number of years of competitive swimming, an increase in breaststroke training distance and a decrease in warm-up distance existed. Furthermore, according to a study by McMaster and Troup (1993), regarding the prevalence of shoulder pain in competitive swimmers, they found a relationship existed between shoulder pain and weight training, the use of hand paddles, the use of a kickboard, stretching and a variety of resistance activities, in aggravating shoulder pain. It was concluded that a swimmers stroke and a correct technique in the various aspects of training play a vital role in injury prevention (Veni *et al.*, 1999).

Much research has been completed in the individual stroke phases as well as individual injuries (Grote, Lincoln and Gamble, 2004; Rovere and Nichols, 1985) associated with the stroke phases. However, no profile of these injuries exists for the South African swimming population generally. Thus this research aims to develop a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area. This would create a starting point for understanding the injuries present and thus be able to address factors that may predispose competitive swimmers to injuries.

1.4 Limitations of the study

A study such as this requires the participant's willingness to participate in the study. It also requires that the participants answer the questionnaire with honesty and truthfulness, based on the fact that their responses remain anonymous. It is also assumed that the respondent, under the supervision of the researcher and their parents (if under the age of 18), understand the questionnaire and the information that is required from them.

In addition to the above it is also noted that the lifetime incidence of injuries under study may well be an under estimation when compared to the reality experienced by the swimmer. It has been suggested by Mouton (1996) that the principle reason for this is 'memory decay'.

1.5 Conclusion

No studies have been found regarding the profile of musculoskeletal injuries in competitive swimmers in South Africa, or with particular reference to the greater Durban area. Therefore the aim of this study was to determine a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa; in order to determine if any relationships exist between risk factors identified in other studies and the swimming injuries highlighted in this study, and to compare these results to International data.

In this chapter an introduction to competitive swimming and a background to the sport and the reason for study were provided. In Chapter Two, a definition of swimming will be provided, as well as an explanation of the classification of swimmers with respect to the stroke they swim. Relevant information and results from related studies, pertaining to swimming injuries and potential risk factors are then discussed. In Chapter Three, the materials and methods used in this study are discussed and explained. The process of statistical analysis will also be included in this chapter. Chapter Four, deals with the results obtained in the study, as well as a discussion of each result and how it compares with the results of other relevant studies. In Chapter Five, conclusions are drawn from this study, and recommendations are provided for future studies.

Chapter 2

Literature Review

2.1 Introduction

This chapter provides the reader with a definition of swimming, and explains the various swimming strokes (biomechanics) related to the sport as well as the equipment utilized, in order to contextualise the possible injuries that swimmers can sustain.

In this respect it is noted that swimming is very popular as both a competitive as well as a recreational sport (Johnson *et al.*, 1987). Great improvements have been made in the sport of swimming over the past 20 years, with regards to training techniques, flexibility exercises, weight training programs and the equipment that is used (Johnson *et al.*, 1987). Therefore, in order to begin to understand the possible risk factors and resultant injuries it is important to understand the biomechanics of swimming.

2.2 Definition of swimming

Swimming can be defined as the act of moving the body through the water by using the arms and legs. Swimming is a popular form of recreation, an important international sport, and a healthy exercise (Van Rossen, 1991; Watkins, 1996; Kammer *et al.*, 1999).

Competitive swimmers can be divided into a number of categories according to their stoke – Butterfly, Backstroke, Breaststroke, Freestyle or Individual Medley (IM); and the distance they swim – Sprinters, Middle distance or Long distance swimmers.

2.3 Biomechanics of Swimming

2.3.1 Drag (Total Drag)

In order to fully understand the biomechanics of swimming, it is necessary to examine the biomechanics of each of the four swimming strokes but also understand the mechanics and forces specific to water known as 'hydrodynamics'. Hydrodynamics is defined as the science relating to the forces of liquids in motion, and the forces acting on a solid body immersed in fluid and the motion relative to them (Shamus and Shamus, 2001).

Therefore, total drag can be defined as the resistance forces acting on a swimmer's body while in motion within a fluid medium (Polidori, G; Taiar, R; Fohanno, S; Mai, T.H and Lodini, A 2006). An example is that a swimmers speed is not only a result of their ability to produce powerful propulsion forces to move forward through the still water but most of the power produced by them is used to dissipated the moving water. Therefore, a swimmer generates greater forward propulsion when pushing against still water than moving water (Shamus and Shamus, 2001).

It is important to understand the mechanical factors that are unique to water. These being: 'Form Drag', 'Wave Drag' and 'Frictional Drag'.

2.3.1.1 Form Drag

Form drag is defined by Shamus and Shamus (2001) as "the resistance exerted on the body depending on the body's position as it moves in the water". Form drag will be at its least when the body is in a horizontal position (Polidori *et al.*, 2006). Therefore, any deviation of the body from the horizontal position will result in an increase in the swimmer's surface area which would therefore increase the form drag. Lateral deviation of the swimmer's body, due to incorrect swimming technique, will also cause an increase in the form

drag, because the lateral movement of the swimmer increases the frontal surface area thereby slowing down the forward movement of the swimmer through the water. So a horizontal body position allows the swimmer to be the most streamlined in the water and therefore able to swim faster.

Shamus and Shamus (2001), also state that less resistance is experienced when swimming underwater as the greatest form drag is at the surface of the water. This explains why competitive swimmers will remain underwater for as long as possible after their starts and turns (Shamus and Shamus, 2001; Polidori *et al.*, 2006).

2.3.1.2 Wave Drag

Shamus and Shamus (2001), described wave drag as the increase of resistance in the water due to the wavelike motion or turbulence created when the swimmer is swimming in the pool. As the swimmer swims the water in the pool bounces off the sides and floor of the swimming pool creating turbulence. Wave drag contributes up to 60% of the total drag (Polidori *et al.*, 2006).

Wave drag can be decreased by using special designed wave-dispersing lane ropes, which aid in controlling the movement of water between lines. The depth of the swimming pool also plays a role in decreasing wave drag. The deeper the swimming pools the less chance the water has to rebound off the bottom of the pool. Thus the design and use of the lane ropes and depth of the swimming pool play a role in the speed of the swimming pool (Shamus and Shamus, 2001). Rules and regulations are set in the design of the competition swimming pools, to provide the best possible environment and facilities for the swimmer (Fina, 2006).

2.3.1.3 Frictional Drag

Frictional drag is the friction produced between the swimmers body and the water molecules. Surface smoothness plays an important role in frictional drag. The smoother the surface the less friction is present (Maglischo, 1982).

This explains the shaving down rituals swimmers undergo prior to any major event. Swimming costumes, caps and goggles are all designed and specific materials are used in order to reduce frictional drag (Maglischo, 1982).

The Form, Wave and Frictional Drag when combined with the powerful motion of the swimmer through the water play a major role in the swimmers performance and prevalence of injury (Shamus and Shamus, 2001).

2.3.2 Swimming techniques and drag

2.3.2.1 Starts and turns

In Freestyle, Breaststroke and Butterfly the swimmer dives off a starting block into the water. The majority of swimmers use the *Pike Dive*, which was made popular in the mid 1960's, when coaches and athletes realized that there was less resistance to forward propulsion below the water surface (Ferrell, 1999).

Underwater swimming is of great importance as there is a minimal amount of drag (form and wave) and this can increase an elite swimmers potential speed by up to 40% (Polidori *et al.*, 2006). However underwater swimming in races is limited to the first 15m after the swimmers start or turn (Ferrell, 1999). The more streamlined the swimmer is in the water the less the frictional drag there will be (Polidori *et al.*, 2006). Less resistance is experienced when swimming underwater as the greatest Form Drag is at the surface of the water (Shamus and Shamus, 2001), thus explaining why competitive swimmers will remain underwater for as long as possible after their starts and turns (Shamus and Shamus, 2001; Polidori *et al.*, 2006).

2.3.2.2 Strokes and their drag

Drag plays an important role in the success of a swimmer. A swimmer's speed does not solely rely on their ability to produce a powerful propulsion force to move forward through the water, but also their ability to decrease the amount of energy needed to move the water (Shamus and Shamus, 2001). The more streamlined the swimmer is in the water the less the frictional drag there will be (Polidori *et al.*, 2006).

Therefore, the stroke technique also plays a role in a swimmer's ability to decrease drag. By maintaining a horizontal position with no lateral movements of the body while swimming the swimmer will decrease their form drag. An increased shoulder roll as it decreases drag and increases power of the pull by placing the shoulder in a less stressful position (Jones, 1999).

Breaststroke swimmers' that use the undulation of the Butterfly stroke type kick improves the swimmers forward propulsion and decreases the frontal drag (Shamus and Shamus, 2001; Jones, 1999).This style of Breaststroke is believed to decrease the form drag and increase the speed of the stroke (Jones, 1999). As apposed to the flat style were there is little up and down movement of the body and the swimmer relies on flexibility of the neck (Jones, 1999).

Body shaving or 'shaving down' is very common among competitive swimmers prior to a major event. Studies have shown that shaving body hair reduces surface drag (Jones, 1999). Although it is believed that 'shaving down' also improves the afferent impulses to the central nervous system thus improving the brain's and spinal cord's ability to coordinate motor unit recruitment. This in turn improves the quality of the motor output, giving the body a better judgement in the water and thus reducing frontal drag (Jones, 1999).

2.4 Biomechanics of the specific swimming strokes

In order to fully understand and discuss the biomechanics unique to each specific swimming stroke, this paper will identify the differences in these stokes and for the purpose of this study, will highlight the general mechanics of the swimming stroke by assessing the similarities between them before discussing the biomechanics of each individual stroke.

When comparing the four competitive swimming strokes, namely Butterfly, Backstroke, Breaststroke and Freestyle (Crawl) there are a number of similarities that exist regarding the motion of the upper limbs (Shamus and Shamus, 2001).

In Freestyle and Backstroke the arms are used in an asymmetrical reciprocal pattern, with an alternating pattern of hand entry into the water. In Butterfly and Breaststroke, the arm movement used is bilateral and symmetrical; the arms enter and exit the water simultaneously (Shamus and Shamus, 2001)

The use of the lower limbs varies significantly between the different strokes. In Freestyle and Backstroke, the kick is an alternating beat kick, also referred to as a *flutter kick*. In Butterfly a bilateral symmetrical undulating motion, is used this kick is referred to as the *dolphin kick*. The Breaststroke kick, also known as the *whip kick*, is performed by a bilateral symmetrical use of the lower limbs, in which the legs are flexed towards the trunk and forcefully thrust out, the legs are extended, external rotated and adducted (Shamus and Shamus, 2001).

Performance and development is directed at the four phases that are found in each stroke, the 'reach' or 'entry', 'catch', 'pull or power' and 'recovery' phase (Fu and Stone, 1994). Briefly *the reach or entry phase* is when the arm reaches forward to enter the water. *The catch*: is where the elbow is flexed 100°, the shoulder extends, horizontally abducts and medially rotates. *The pull or power phase* produces the majority of power for propulsion, except in

Breaststroke, it is unique as the upper and lower limbs move through the water bilaterally. The pull phase in Butterfly, Backstroke and Freestyle includes the movements of the arms through the water starting at hand entry and proceeding through adduction and internal rotation of the glenohumeral joint. This phase may also include the insweep and outsweep (Shamus and Shamus, 2001). *The recovery phase,* also referred to as the out-of-water phase, except in Breaststroke, is characterised by arm abduction and internal rotation. The arm is returned to the reach position and so the cycle continues (Fu and Stone, 1994).

2.4.1 Butterfly

Shamus and Shamus, (2001) described the Butterfly stroke as a bilateral symmetrical overhead motion of the arms, combined with a simultaneous bilateral symmetrical undulating motion of the legs, referred to as the *Dolphin Kick.*

Butterfly is a bilateral symmetrical movement, the hips act as a short axis for undulation. In addition and due to the lack of rotation from the torso, this position therefore results in an increase in the protraction and abduction of the scapula, to achieve the depth in the water required to create a powerful stroke (Maglischo, 1982).

The hands should enter the water in line with or slightly outside the shoulder, with the palms of the hand at a 45 degree angle, to ensure minimal drag as the swimmer's hand enters the water (Maglischo, 1982). As the hand enters the water, the elbows are extended, the hands move outwards in a curvilinear pattern until the arms pass the shoulder, this is where the catch phase begins (Maglischo, 1982). The catch phase begins with the forearms pronated, the shoulders abducted, the scapula protracted and abducted and the elbows flexed slightly (Shamus and Shamus, 2001). After the catch phase the pull phase of the stroke begins. During the pull phase the latissimus dorsi, subscapularis, teres major and pectoralis major muscles are forcefully

adducted. The glenohumeral (GH) joint is internally rotated, followed by a forceful shoulder and elbow extension indicating the end of the power phase.

The shoulders are brought overhead and are internally rotated by the anterior and medial deltoid, supraspinatus, infraspinatus and teres minor (Jones, 1999) during the recovery phase of the stroke.

During each Butterfly stroke the elbows are flexed and extended. During flexion the biceps brachii and coracobrachialis muscles are used. Where as the triceps brachii muscles are used in extension. The wrist flexors and extensors muscles are used during the sculling action.

It is essential that the trunk of a Butterfly swimmer remains stable because of the bilateral symmetrical use of the upper limbs. The Butterfly swimmer should remain in the same plane as the surface of the water, with the hips and shoulders rocking in an undulating motion. The swimmers arms may clear the water during the recovery phase of the stroke, but the shoulders must re-enter the water immediately after the hands enter the water.
A Butterfly swimmer's trunk stabilization muscles are essential for propulsion of the trunk through the water (Shamus and Shamus, 2001).

In the Butterfly stroke a d*olphin kick* is performed by the lower limbs. The dolphin kick is a bilateral symmetrical movement, consisting of two distinct phases, the upward and the downward beat. The legs move together in a rhythm of two kicks per one arm stroke.

The downward movement of the kick begins with a forceful flexion of the trunk and flexion of the hips. The abdominal muscles are active in this phase. Knee flexion followed by a forceful knee extension, until the knee is fully extended, complete the downward beat to the dolphin kick.

During the upward beat the knees remain fully extended and the ankle joint is plantarflexed allowing for a maximum surface area for foot propulsion. During

this phase the abdominal muscles, gluteus muscles erector spinae and hamstring muscles (Moore and Dalley, 1999) are most active. Gastrocnemius and soleus muscles are primarily responsible for maintaining ankle palantarflexion (Shamus and Shamus, 2001). The dolphin kick is most effective in the Butterfly stroke in a ratio of two downward beats to every one arm stroke. The first down beat takes place as the hands enter the water at the catch phase of the stroke. The second down beat, which plays a major role in providing a powerful force, occurs at the end to the pulling phase (Shamus and Shamus, 2001). In the Butterfly the timing of the upper and lower limbs is essential to fully mastering the stroke (Jones, 1999).

Table 2.1 Muscles used in swimming Butterfly (Moore and Dalley, 1999; Travell and Simons 1999; Travell and Simons 1993)

Muscle	Origin	Insertion	Action
Latissimus dorsi	Spinous processors of inferior 6 thoracic vertebrae, Thoracolumbar fascia, iliac crest and the inferior 4 ribs	Intertubercular groove of the humerus.	Extends, adducts and internally rotates the humerus.
Subscapularis	Subscapular fossa	Lesser tubercle of the humerus	Internally rotates the arm and adducts it. Helps hold the humeral head in the glenoid cavity.
Teres major	Dorsal surface of the inferior angle of the scapula	Intertubercular groove of the humerus.	Adducts and internally rotates the arm.
Teres minor	Superior part of the der of the scapula	Inferior facet of the greater tubercle of the humerus	Externally rotates the arm and helps hold the humeral head in the glenoid cavity.
Pectoralis major	Clavicles head: anterior surface of the medial half of the clavicle. Sternocostal head: anterior surface of the sternum, superior 6 costal cartilages.	Lateral lip of the intertubercular groove of the humerus	Adducts and internally rotates the head of the humerus. Draws the scapula anteriorly and inferiorly
Deltoid	Lateral third of clavicle, acromion and the spine of the	Deltoid tuberosity of the humerus	Anterior: flexes and internally rotates the arm.

	scapula		Medial: abducts the arm Posterior: extends and externally rotates the arm.
Supraspinatus	Supraspinous fossa of the scapula	Superior facet of the greater tubercle of the humerus	Abduction of the arm
Infraspinatus	Infraspinous fossa of the scapula	Greater tubercle of the humerus	Externally rotates the arm and helps hold the humeral head in the glenoid cavity.
Biceps brachii	Short head: Coracoid process of the scapula Long head: supraglenoid tubercle of the scapula	Tuberosity of the radius via the Bicipital aponeurosis	Supinates the forearm, flexes the forearm
Coracobrachialis	Coracoid process of the scapula	Middle of the medial border of the humerus	Flexes and adducts the arm
Triceps brachii	Long head: infraglenoid tubercle of the scapula Lateral head: posterior surface of the humerus and the superior radial groove Medial head: posterior surface of the humerus and the inferior radial groove.	Olecranon of the ulna	Extends forearm Long head, stabilises the head of the humerus when the arm is abducted
Gluteus muscles ○ Gluteus maximus	Ilium posterior to the posterior Gluteal line, dorsal surface of the sacrum and coccyx and sacrotuberous ligament	Iliotibial tract that insert on the lateral condyle of the tibia. Other fibres insert on the Gluteal tuberosity of the femur.	Extends thigh, lateral rotation of the thigh.
○ Gluteus medius	External surface of the ilium, between the anterior and superior Gluteal lines	Lateral surface of greater trochanter of the femur.	Abducts and medially rotates thigh
○ Gluteus minimus	External surface of the ilium, between the anterior and inferior Gluteal lines	Anterior surface of the greater trochanter of the femur.	Abducts and medially rotates thigh
Gastrocnemius	Lateral head: lateral aspect of the lateral femoral	Posterior surface of the calcaneus via the calcaneal tendon	Plantarflexes the ankle when the knee is extended. Raises the

	condyle. Medial head: popliteal surface of the femur superior to the medial femoral condyle.		heel during walking and flexes the leg at the knee joint.
Soleus	Posterior aspect of the fibula head and medial boarder of the tibia	Posterior surface of the calcaneus via the calcaneal tendon	Plantarflexes the ankle independent of the knee position and steadies the foot
Hamstring ○ Semitendinosus	Ischial tuberosity	Medial surface of the superior part of the tibia	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Semimembranosus	Ischial tuberosity	Posterior part of the medial tibial condyle, lateral to the femoral condyle	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Biceps Femoris	Long head: Ischial tuberosity Short head: linea aspera and lateral supracondylar line of the femur	Lateral aspect of the fibula head. The tendon splits at this site by the fibular collateral ligament of the knee	Flexes the leg and rotates it laterally when the knee is flexed. Extends the thigh

2.4.2 Backstroke

In Backstroke the swimmer is in a supine position in the water, their extended arms move in an alternating motion over their head and the legs perform a *flutter kick*. In a Backstroke event the swimmer must remain on there back for the duration of the race, except during turns. Although the swimmer is in the supine position during Backstroke, there is a large amount of side to side rolling (Shamus and Shamus, 2001).

Backstroke can be divided into four phases, the 'hand entry', 'catch', 'pull-through' and the 'recovery' phase.

In the hand entry phase, the little finger should enter the water first, with the elbow fully extended and the palm of the hand facing outwards. The arm enters the water in front of the head in line with the shoulders (Maglischo, 1982).

The catch phase begins immediately after hand-entry. In this phase the hand moves forward, downwards and outwards and the palm of the hand rotates to form a downward pitch, to allow for the lift force to be exerted by the hand. In this phase the elbow is flexed to prepare for the power/ propulsive phase of the arm stroke to begin (Maglischo, 1982). In this phase the glenohumeral joint is externally rotated, while the elbow is flexed (Shamus and Shamus, 2001).

The pull-through or power phase occurs underwater. It begins immediately after the catch phase. The pull-through phase can be subdivided into the initial down sweep, upsweep and final down sweep (Maglischo, 1982). During the initial down sweep, the hand moves in a circular path sweeping downwards into the water. The shoulder and hips rotate towards the down sweeping arm. The swimmer's hand is usually slightly cupped in order to produce a more forceful lift. The swimmer's hand is moves downwards, outwards and in a backwards direction. In the upsweep motion begins as the hand moves outwards at the end of the down sweep, allowing the hand to change direction to an upward direction. The hand continues to move in an upward, backward and inward motion. The swimmer's elbow is flexed more than 90 degrees as the upsweep of the arm stroke comes to an end, allowing for the final down sweep to begin (Shamus and Shamus, 2001).

The propulsive force is maintained during the change of hand position from an upward direction to a downward one. The hand then moves downward and inward until the elbow is fully extended and the hand is next to the thigh (Maglischo, 1982).

During this process the glenohumeral joint is adducted and internally rotated during the pull-through phase and the elbow is forcefully extended at the end of this phase (Shamus and Shamus, 2001).

The recovery phase in Backstroke occurs above the water. In this phase the shoulder is flexed and internally rotated, the swimmer's elbow is in a fully extended position with the forearm pronated (Shamus and Shamus, 2001). The swimmers hand exits the water by rolling their shoulder upwards, while the body rolls downwards as the opposite hand enters the water, therefore allowing the recovering arm to be out of the water.

In Backstroke the body roll is an essential part of mastering the stroke, as it positions the muscles required for propulsion in their most advantageous position and places the glenohumeral joint and its surrounding musculature in a position to produce least possible stress (Shamus and Shamus, 2001). An increased shoulder roll as it decreases drag and increases power by placing the shoulder in a less stressful position (Jones, 1999). It is important the swimmer's head remains in a fixed position while the shoulder, trunk and hips rotate, ensuring that they remain in the same line as the head. The body roll allows for the pull-through arm to reach deeper into the water and for a better recovery with the opposite arm (Shamus and Shamus, 2001).

The *Flutter Kick* is used in Backstroke, in either a four or six-beat configuration. The *Flutter kick* is performed by using forceful hip flexion and extension in combination with flexion and extension of the knee and plantarflexion of the ankle. Gluteus, quadriceps and the hamstring muscles are the primary muscles used in the *Flutter kick* (Shamus and Shamus, 2001).

Table 2.2 Muscles used in swimming Backstroke (Moore and Dalley, 1999; Travell and Simons 1999; Travell and Simons 1993)

Muscle	Origin	Insertion	Action
Latissimus dorsi	Spinous processors of inferior 6 thoracic vertebrae, Thoracolumbar fascia, iliac crest and the inferior 4 ribs	Intertubercular groove of the humerus.	Extends, adducts and internally rotates the humerus.
Teres major	Dorsal surface of the inferior angle of the scapula	Intertubercular groove of the humerus.	Adducts and internally rotates the arm.
Teres minor	Superior part of the lateral border of the scapula	Inferior facet of the greater tubercle of the humerus	Externally rotates the arm and Helps hold the humeral head in the glenoid cavity.
Deltoid	Lateral third of clavicle, acromion and the spine of the scapula	Deltoid tuberosity of the humerus	Anterior: flexes and internally rotates the arm. Medial: abducts the arm Posterior: extends and externally rotates the arm.
Supraspinatus	Supraspinous fossa of the scapula	Superior facet of the greater tubercle of the humerus	Abduction of the arm
Infraspinatus	Infraspinous fossa of the scapula	Greater tubercle of the humerus	Externally rotates the arm and Helps hold the humeral head in the glenoid cavity.
Subscapularis	Subscapular fossa	Lesser tubercle of the humerus	Internally rotates the arm and adducts it. Helps hold the humeral head in the glenoid cavity.
Pectoralis major	Clavicles head: anterior surface of the medial half of the clavicle. Sternocostal head: anterior surface of the sternum, superior 6 costal cartilages.	Lateral lip of the intertubercular groove of the humerus	Adducts and internally rotates the head of the humerus. Draws the scapula anteriorly and inferiorly
Trapezius	Medial 1/3 of superior nuchal line, external occipital protuberance and spinous processors of C7- T12 vertebrae	Lateral third of the clavicle, acromion and the spine of the scapula	Elevates, retracts and rotates the scapula
Levator scapula	Posterior tubercles of C1-C4 transverse processors	Superior part of the medial border of the scapula	Elevates the scapula and rotes the scapula thus tilting the glenoid cavity inferiorly.

Rhomboid	Minor: nuchal ligament, spinous processors of C7 and T1 Major: spinous processors of T2-T5	Medial boarder of the scapula	Retracts scapula and rotates it to depress the glenoid cavity.
Quadriceps ○ Rectus Femoris	Anterior iliac spine and ilium superior to the acetabulum.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee, stabilises the hip joint and aids Iliopsoas flex the hip.
○ Vastus lateralis	Greater trochanter and the lateral lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
○ Vastus medialis	Intertrochanteric line and the medial lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
○ Vastus intermedius	Anterior and lateral surface of body of the femur.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
Gluteus muscles ○ Gluteus maximus	Ilium posterior to the posterior Gluteal line, dorsal surface of the sacrum and coccyx and sacrotuberous ligament	Iliotibial tract that insert on the lateral condyle of the tibia. Other fibres insert on the Gluteal tuberosity of the femur.	Extends thigh, lateral rotation of the thigh.
○ Gluteus medius	External surface of the ilium, between the anterior and superior Gluteal lines	Lateral surface of greater trochanter of the femur.	Abducts and medially rotates thigh
○ Gluteus minimus	External surface of the ilium, between the anterior and inferior Gluteal lines	Anterior surface of the greater trochanter of the femur.	Abducts and medially rotates thigh
Hamstring ○ Semitendinosus	Ischial tuberosity	Medial surface of the superior part of the tibia	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Semimembranosus	Ischial tuberosity	Posterior part of the medial tibial condyle, lateral to the femoral condyle	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.

• Biceps Femoris	Long head: Ischial tuberosity Short head: linea aspera and lateral supracondylar line of the femur	Lateral aspect of the fibula head. The tendon splits at this site by the fibular collateral ligament of the knee	Flexes the leg and rotates it laterally when the knee is flexed. Extends the thigh

2.4.3 Breaststroke

The upper limb movement in Breaststroke is described by Shamus and Shamus (2001) as a bilateral and symmetrical movement in which the arms are required to move simultaneously in a horizontal plane. The bilateral movement of the arms alternates with the bilateral leg movement, also referred to as the Breaststroke or *Whip Kick* (Rodeo, 1999). The sequence of the Breaststroke stroke is pull, breathe, kick and glide (Shamus and Shamus, 2001).

Breaststroke can be divided into the catch and the insweep (the pull-through phase). The catch phase can be divided into the upsweep and outsweep, where the swimmers arms are fully extended with the hands out-stretched in front of the body, with their palms facing away from each other. The forearm is pronated, with the wrists flexed slightly and the shoulder is internally rotated. Their arms then move in an outward and upward motion. This action causes the posterior deltoid, infraspinatus and teres minor muscles contract (Moore and Dalley, 1999). The outsweep continues until the hands are wider than the shoulder width apart. The elbows remain extended in this phase (Shamus and Shamus, 2001). The arms move in a circular motion.

The rotation of the palms inward and downwards indicates the beginning of the insweep phase of the stroke. The insweep is a lateral sculling motion as the hands move towards the shoulders. During this phase the forearm is supinated and the shoulder is externally rotated. The muscles active in this phase are biceps brachii and the supinator muscles, they cause the forearm supination and infraspinatus and teres minor (Moore and Dalley, 1999) assisted with the shoulder external rotation (Shamus and Shamus, 2001).

The pull-through phase starts with contraction of the pectoralis major, teres major, latissimus dorsi and anterior deltoid muscles which cause the shoulders and arms to adduct (Moore and Dalley, 1999). In the pull-through phase the elbows are flexed by biceps brachii and coracobrachialis. (Moore and Dalley, 1999) During this phase adduction of the arms and shoulders continues until the hands and elbows are together beneath the chest (Shamus and Shamus, 2001).

As the hands come together at the end of the insweep, the recovery phase begins. The recovery phase occurs when both the arms move forward, with the fingertips leading the way, with palms of the hands facing each other. It is essential that the hands remain in a streamline position. The recovery phase continues until the arms are fully extended in front of the body (Shamus and Shamus, 2001).

The *Whip or Breaststroke Kick* is divided into the power phase and the recovery phase. The power phase is subdivided into the outsweep and insweep. The outsweep phase of the kick begins with the knees acing laterally flexed at 90 degrees and the feet being brought close to the buttocks. The swimmers feet are everted, thus the soles of the feet face away from the swimmer. The feet are everted and the hip is internally rotated. The everted position of the foot is important to allow for maximal propulsion, because of the increased surface area covered as the feet move through the water. The feet move in an outward, downward and backward motion. During the outsweep phase the knees move slightly wider than the hips and the feet are slightly wider than the knees (Shamus and Shamus, 2001).

The insweep or propulsion phase of the whip kick begins at the widest point of the kick pattern. At this point the knees are under significant valgus stress (Jones, 1999). The feet continue in a downward, backward and inward motion until the feet come together and the knees and hips are fully extended, causing a powerful propulsive force. During the insweep adduction of the legs and a degree of external rotation at the hips also occurs. In order for the kick

to end in a streamlined position the ankles are plantarflexed (Shamus and Shamus, 2001).

At the end of the power phase of the kick the swimmer glides, allowing for the recovery phase of the kick to occur. In the recovery phase the knees are flexed to 90 degrees and the feet are brought up towards the buttocks. There is also a degree of hip flexion that takes place during this phase.

Alternatively some Breaststroke swimmers lift their upper body out of the water during breathing and then plunge there shoulders below the surface of the water in the kick phase, resulting in a motion similar to that found in Butterfly. The swimmer pushes their sternum to the bottom of the pool towards the end of the kick and into the glide phase of the stroke. The hips drop as the swimmer prepares to kick and breathe. This style of Breaststroke is believed to decrease the form drag and increase the speed of the stroke (Jones, 1999). The undulation of the Butterfly stroke type kick also improves the forward propulsion in Breaststroke (Shamus and Shamus, 2001) and decreases the frontal drag (Jones, 1999).

Table 2.3 Muscles used in swimming Breaststroke (Moore and Dalley, 1999; Travell and Simons 1999; Travell and Simons 1993)

Muscle	Origin	Insertion	Action
Deltoid	Lateral third of clavicle, acromion and the spine of the scapula	Deltoid tuberosity of the humerus	Anterior: flexes and internally rotates the arm. Medial: abducts the arm Posterior: extends and externally rotates the arm.
Teres major	Dorsal surface of the inferior angle of the scapula	Intertubercular groove of the humerus.	Adducts and internally rotates the arm.
Teres minor	Superior part of the lateral border of the scapula	Inferior facet of the greater tubercle of the humerus	Externally rotates the arm and Helps hold the humeral head in the glenoid cavity.
Pectoralis major	Clavicles head: anterior surface of the medial half of the clavicle. Sternocostal head: anterior surface of the sternum, superior 6 costal cartilages.	Lateral lip of the intertubercular groove of the humerus	Adducts and internally rotates the head of the humerus. Draws the scapula anteriorly and inferiorly.

Biceps brachii	Short head: Coracoid process of the scapula Long head: supraglenoid tubercle of the scapula	Tuberosity of the radius via the Bicipital aponeurosis	Supinates the forearm, flexes the forearm.
Coracobrachialis	Coracoid process of the scapula	Middle of the medial border of the humerus	Flexes and adducts the arm.
Latissimus dorsi	Spinous processors of inferior 6 thoracic vertebrae, Thoracolumbar fascia, iliac crest and the inferior 4 ribs	Intertubercular groove of the humerus.	Extends, adducts and internally rotates the humerus.
Infraspinatus	Infraspinous fossa of the scapula	Greater tubercle of the humerus	Externally rotates the arm and Helps hold the humeral head in the glenoid cavity.
Triceps brachii	Long head: infraglenoid tubercle of the scapula Lateral head: posterior surface of the humerus and the superior radial groove Medial head: posterior surface of the humerus and the inferior radial groove.	Olecranon of the ulna	Extends forearm Long head, stabilises the head of the humerus when the arm is abducted.
Peroneus Longus	Head and superior part of the fibula	Base of the 1st metatarsal and medial cuneiform	Everts the foot and act as a weak plantar flexor of the ankle.
Peroneus Brevis	Inferior part of the lateral side of the fibula	Doral surface of the tuberosity on the lateral side of the base of the 5th metatarsal	Everts the foot and act as a weak plantar flexor of the ankle.
Iliopsoas ○ Psoas major	T12-L5 vertebra and discs, transverse processors of all lumbar vertebra	Lesser trochanter of the femur	Flex thigh at hip joint and stabilize hip joint.
○ Psoas minor	T12-L1 vertebra and discs,	Pectineal line	Flex thigh at hip joint and stabilize hip joint.
○ Iliacus	Iliac crest, iliac fossa, sacrum and anterior sacroiliac ligaments	Psoas major tendon, lesser trochanter and distal femur.	Flex thigh at hip joint and stabilize hip joint.

Gluteus muscles ○ Gluteus maximus	Ilium posterior to the posterior Gluteal line, dorsal surface of the sacrum and coccyx and sacrotuberous ligament	Iliotibial tract that insert on the lateral condyle of the tibia. Other fibres insert on the Gluteal tuberosity of the femur.	Extends thigh, lateral rotation of the thigh.
○ Gluteus medius	External surface of the ilium, between the anterior and superior Gluteal lines	Lateral surface of greater trochanter of the femur.	Abducts and medially rotates thigh.
○ Gluteus minimus	External surface of the ilium, between the anterior and inferior Gluteal lines	Anterior surface of the greater trochanter of the femur.	Abducts and medially rotates thigh.
Hamstring ○ Semitendinosus	Ischial tuberosity	Medial surface of the superior part of the tibia	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Semimembranosus	Ischial tuberosity	Posterior part of the medial tibial condyle, lateral to the femoral condyle	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Biceps Femoris	Long head: Ischial tuberosity Short head: linea aspera and lateral supracondylar line of the femur	Lateral aspect of the fibula head. The tendon splits at this site by the fibular collateral ligament of the knee	Flexes the leg and rotates it laterally when the knee is flexed. Extends the thigh.
Quadriceps ○ Rectus Femoris	Anterior iliac spine and ilium superior to the acetabulum.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee, stabilises the hip joint and aids Iliopsoas flex the hip.
○ Vastus lateralis	Greater trochanter and the lateral lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee.
○ Vastus medialis	Intertrochanteric line and the medial lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee.
○ Vastus intermedius	Anterior and lateral surface of body of the femur.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee.

Gastrocnemius	Lateral head: lateral aspect of the lateral femoral condyle. Medial head: popliteal surface of the femur superior to the medial femoral condyle.	Posterior surface of the calcaneus via the calcaneal tendon	Plantarflexes the ankle when the knee is extended. Raises the heel during walking and flexes the leg at the knee joint.
Soleus	Posterior aspect of the fibula head and medial boarder of the tibia	Posterior surface of the calcaneus via the calcaneal tendon	Plantarflexes the ankle independent of the knee position and steadies the foot.
Tensor Fascia lata	Anterior superior iliac spine and anterior part of iliac crest	Iliotibial tract attaching to the lateral tibia condyle	Abducts, internally rotates and flexes the thigh. Helps keep knee extended.
Sartorius	Anterior superior iliac spine	Superior part of the medial tibia	Flexes, abducts and externally rotates thigh. Helps keep knee extended.
Gracillis	Body and inferior part of the pubic ramus.	Superior part of the medial tibial surface	Adducts the thigh, flexes the leg and assists with medial rotation of the thigh.
Adductors ○ Adductor Longus	Body of the pubis inferior to the pubic crest	Middle 3rd of linea aspera of the femur	Adducts the thigh.
○ Adductor Brevis	Body and inferior pubic ramus	Pectineal line and superior part of the linea aspera of the femur	Adducts and flexes the thigh.
○ Adductor Magnus	Adductor part: pubic ramus and ramus of the ischium Adductor part: Ischial tuberosity.	Adductor part: Gluteal tuberosity, linea aspera and supracondylar line Hamstring part: adductor tubercle of the femur.	Adducts the thigh Adductor part: flexes the thigh. Hamstring part: Extends the thigh.

2.4.4 Freestyle

This stroke is also referred to as crawl. Freestyle is the fastest of all the four competitive strokes. It is described as an alternating movement of the arms in extension over the head with a bilateral alternating kick. The kick is better known as the *Flutter kick* (Shamus and Shamus, 2001).

The Freestyle arm stroke can be divided into the hand entry phase, catch phase, glide or stretch phase, pull-through and recovery phases.

The hand entry phase begins as the hand enters the water. The fingertips enter first to reduce water drag followed by the rest of the hand. The thumb must be position facing slightly downwards. The forearm is pronated and there is internal rotation of the shoulder. The hand should enter the water mid way between the head and shoulder (Shamus and Shamus, 2001). The arm is slightly flexed, the elbow in a higher position than the hand. As the wrist and elbow enters the water the arm reaches forward to full extension. This is the glide or stretch phase of the stroke, the arm continues to move forward until the arm is fully extended, the wrist remains in a neutral position with the palm of the hand facing downwards. The timing of the stretch should correspond with the start of the recovery phase of the opposite arm (Maglischo, 1982).

The catch phase follows with the wrist flexed approximately 40 degrees, the hand is rotated outwards and the elbow begins to flex. It is essential that the swimmer has a powerful catch, after the catch the hand speed should increase in a downward and outward motion to begin the pull-through phase of the stroke (Maglischo, 1982).

The pull-through phase can be divided into the downsweep, insweep and upsweep according to Maglischo (1982). In the downsweep the hand moves in a curvilinear path downwards and outwards. The outward motion of the hand should occur naturally as the shoulder rolls into the stroke, as it follows the downward movement. The elbow joint is flexed gradually in order to maintain the downward motion of the hand. The speed of the downward sweep of the hand increases throughout the duration of the downsweep. The velocity of the downward motion must exceed the velocity of the backward motion (Maglischo, 1982) in order to achieve optimal propulsion through the water and in order to prepare the hand for the next phase of the stroke.

The palm of the hand must be cupped and face in a downward, outward and backwards direction in this phase, thus causing water to move backwards as it moves under the hand (Maglischo, 1982).

The downsweep is the least propulsive phase of the arm stroke, but it is essential that it is performed correctly so the arm is positioned right for the insweep to be effective. At the deepest point of the stroke the downsweep rounds-off into the insweep phase of the pull-through. As the hand nears the deepest point of the downsweep, the hand motion is rounded-off, from a downward and outward movement in the downsweep to an inward, upward and backward motion as the hand moves from a position outside the shoulder moving under the body and towards the midline, during the insweep. As the hand approaches the midline of the body the inward, upward and backward motion of the hand sweep is accelerated. The angle of the hand changes from an outward, downward and backward position to an inward, upward and backward position, thus causing the water to push backwards as it passes over the palm, thumb and fingers. The insweep is completed either when the hand is at the midline under the body or when the hand is between midline and the outer border of the body, depending the swimmers ability to attain the inward and upward pitch early in the insweep. The inward sweep is greater on the side opposite the swimmer's breathing side as the body roll is greater on the breathing side and thus a larger insweep is needed to move the body back to the prone position (Maglischo, 1982).

During the upsweep the hand is pushed backwards as the hand movement and pitch are changing from an inward to an outward position. The upsweep begins as the hand passes under the swimmer's head. The hand pushes directly backwards from the chest to the waist. As the hand reaches the hip, the hand motion is accelerated in an outward, upward and backward direction until the hand reaches the thigh. The palm of the hand is rotated inward thus allowing the hand to exit the water with minimal drag. The swimmer's elbow is flexed as the hand exits the water. This indicates the start of the recovery phase of the Freestyle stroke. The hand speed is increased as the hand moves outwards and then upwards during the upsweep. The upsweep is the most propulsive phase of the stroke (Maglischo, 1982).

The main purpose of the recovery phase when swimming Freestyle is to position the hand in the correct position for the next arm stroke (Maglischo, 1982). The recovery phase of Freestyle can be divided into the elbow lift, mid-recovery and hand entry. During the recovery phase the arm is out of the water and is reaching forward. The arm should be kept as relaxed as possible to ensure it has time to rest before the start of the next stroke cycle. In the recovery phase the elbow is flexed and kept high out of the water (Shamus and Shamus, 2001).

In Freestyle there are two distinct recovery styles, the high-elbow recovery and the hand-swing recovery. Of the two, the high-elbow recovery is the more popular as it conserves more energy (Maglischo, 1982). For this style, the elbow exits the water and begins to move forward while the hand is finishing the upsweep. The elbow is flexed and moves in an upward and forward direction after exiting the water, the forearm and hand follow the path of the elbow. The palm of the hand is rotated inwards as it exits the water with the little finger leaving the water first, thus a minimal amount of drag will be experienced. During the first half of the recovery phase of the stroke, the arm moves in an upward, outward and forward motion. As the hand reaches for the entry position the arm moves in a forward, inward and downward motion. The arm must begin reaching forward preparing for the hand entry as soon as the hand passes the shoulder. The elbow will begin to extend and continues to extend as the hand enters the water (Shamus and Shamus, 2001).

The hand-swing recovery, in this style of recovery the hand leads the movement of the arm over the water and not the elbow, as seen in the high-elbow recover. The elbow will exit the water as in the high-elbow recovery however the arm is extended as the hand exits the water. The hand swings out of the water and is positioned above the elbow. The hand moves upwards, outwards and forwards over the water with the hand high overhead. As the hand is over the shoulder the elbow is flexed in order to bring the hand downwards and inwards. The reach and entry are the same as those in the high-elbow recovery. This style of recovery is seen in swimmers with limited

shoulder flexibility, as the shoulder can externally rotate more. It is also seen to be more common among sprinters than distances swimmers, as sprinters require a more rapid stroke rate (Maglischo, 1982).

In Freestyle, trunk rotation is an important component of the stroke. The upper half of the body rotates between 60 and 80 degrees in either direction during each stroke cycle (Jones, 1999). The body roll allows the shoulder and arm on the pulling side to reach deeper into the water therefore allowing a more powerful pull to be created. It also allows the recovery arm and shoulder to move higher out of the water, so decreasing resistance during the recovery phase. The body roll aids in the movement that extends the arm forward before the catch phase. As a result of the body roll the head of the humerus is able to remain in a more neutral position relative to the scapula, allowing a greater balance to be had between the pectoral and latissimus dorsi muscles (Moore and Dalley, 1999). Accordingly, this will enable the swimmer to have more power per stroke (Shamus and Shamus, 2001). The body roll also reduces the fontal resistance by up to 40%, thus improving a swimmers speed and efficiency through the water (Jones, 1999).

During breathing a degree of cervical spine rotation is required. The degree of rotation is directly related to the amount of trunk rotation, therefore decrease in trunk rotation will result in an increase in cervical rotation (Jones, 1999). Bilateral breathing allows the development of a well balanced range of motion in cervical spine and strengthening of the cervical spine musculature (Shamus and Shamus, 2001).

In Freestyle the flutter kick is used, it is can be used in two patterns either the six-beat kick or the two-beat kick. In the two-beat kick the core muscles are responsible for the power. Each leg does one downbeat and one upbeat per stroke cycle. Whereas, in the six-beat kick the forceful contractions are as a result of contractions of the hip, knee and ankle musculature. In this pattern each leg does three downbeats and three upbeats per arm stroke cycle. A well coordinated kicking sequence is of great importance for an efficient

Freestyle stroke, as it provides the stability to the trunk. The alternating pattern of the flutter kick causes the stabilization to occur.

The downbeat phase of the kick is the most powerful and results in the propulsion. The downbeat is initiated by a forceful contraction of hip flexors, iliopsoas and rectus femoris (Moore and Dalley, 1999) followed by a powerful knee extension by the contraction of quadriceps femoris (Moore and Dalley, 1999). The ankle joint is held in plantarflexion by gastronemius, soleus, tibialis posterior and peroneus longus and brevis muscles (Moore and Dalley, 1999) through out the flutter kick, which allows for a maximal surface area of the foot to be used.

The upbeat of the flutter kick is achieved by active hip extension due to the gluteal, hamstrings and gracillis muscles (Moore and Dalley, 1999). The knee is in full extension and the ankle is plantarflexed. The upbeat phase of the kick is said to be the recovery phase of the legs (Shamus and Shamus, 2001).

Table 2.4 Muscles used in swimming Freestyle (Moore and Dalley, 1999; Travell and Simons 1999; Travell and Simons 1993)

Muscle	Origin	Insertion	Action
Latissimus dorsi	Spinous processors of inferior 6 thoracic vertebrae, Thoracolumbar fascia, iliac crest and the inferior 4 ribs	Intertubercular groove of the humerus.	Extends, adducts and internally rotates the humerus.
Teres major	Dorsal surface of the inferior angle of the scapula	Intertubercular groove of the humerus.	Adducts and internally rotates the arm.
Teres minor	Superior part of the lateral border of the scapula	Inferior facet of the greater tubercle of the humerus	Externally rotates the arm and helps hold the humeral head in the glenoid cavity.
Deltoid	Lateral third of clavicle, acromion and the spine of the scapula	Deltoid tuberosity of the humerus	Anterior: flexes and internally rotates the arm. Medial: abducts the arm Posterior: extends and externally rotates the arm.
Supraspinatus	Supraspinous fossa of the scapula	Superior facet of the greater tubercle of the	Abduction of the arm

		humerus	
Infraspinatus	Infraspinous fossa of the scapula	Greater tubercle of the humerus	Externally rotates the arm and Helps hold the humeral head in the glenoid cavity.
Subscapularis	Subscapular fossa	Lesser tubercle of the humerus	Internally rotates the arm and adducts it. Helps hold the humeral head in the glenoid cavity.
Pectoralis major	Clavicles head: anterior surface of the medial half of the clavicle. Sternocostal head: anterior surface of the sternum, superior 6 costal cartilages.	Lateral lip of the intertubercular groove of the humerus	Adducts and internally rotates the head of the humerus. Draws the scapula anteriorly and inferiorly
Trapezius	Medial 1/3 of superior nuchal line, external occipital protuberance and spinous processors of C7- T12 vertebrae	Lateral third of the clavicle, acromion and the spine of the scapula	Elevates, retracts and rotates the scapula
Levator scapula	Posterior tubercles of C1-C4 transverse processors	Superior part of the medial border of the scapula	Elevates the scapula and rotes the scapula thus tilting the glenoid cavity inferiorly.
Rhomboid	Minor: nuchal ligament, spinous processors of C7 and T1 Major: spinous processors of T2-T5	Medial boarder of the scapula	Retracts scapula and rotates it to depress the glenoid cavity.
Quadriceps ◦ Rectus Femoris	Anterior iliac spine and ilium superior to the acetabulum.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee, stabilises the hip joint and aids Iliopsoas flex the hip.
◦ Vastus lateralis	Greater trochanter and the lateral lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
◦ Vastus medialis	Intertrochanteric line and the medial lip of the linea aspera of the femur	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
◦ Vastus intermedius	Anterior and lateral surface of body of the femur.	Base of the patella via the patella ligament to the tibial tuberosity.	Extend leg at knee
Gastrocnemius	Lateral head: lateral aspect of the	Posterior surface of the calcaneus via the	Plantarflexes the ankle when the knee is

	lateral femoral condyle. Medial head: popliteal surface of the femur superior to the medial femoral condyle.	calcaneal tendon	extended. Raises the heel during walking and flexes the leg at the knee joint.
Soleus	Posterior aspect of the fibula head and medial boarder of the tibia	Posterior surface of the calcaneus via the calcaneal tendon	Plantarflexes the ankle independent of the knee position and steadies the foot
Tibialis posterior	Posterior surface of the tibia and fibula	Tuberosity of the navicular, cuneiform and cuboid, base of the 2^{nd} to 4^{th} metatarsals	Ankle plantarflexion, inverts the foot
Peroneus Longus	Head and superior part of the fibula	Base of the 1^{st} metatarsal and medial cuneiform	Everts the foot and act as a weak plantar flexor of the ankle
Peroneus Brevis	Inferior part of the lateral side of the fibula	Doral surface of the tuberosity on the lateral side of the base of the 5^{th} metatarsal	Everts the foot and act as a weak plantar flexor of the ankle
Gracillis	Body and inferior part of the pubic ramus.	Superior part of the medial tibial surface	Adducts the thigh, flexes the leg and assists with medial rotation of the thigh.
Gluteus muscles ○ Gluteus maximus	Ilium posterior to the posterior Gluteal line, dorsal surface of the sacrum and coccyx and sacrotuberous ligament	Iliotibial tract that insert on the lateral condyle of the tibia. Other fibres insert on the Gluteal tuberosity of the femur.	Extends thigh, lateral rotation of the thigh.
○ Gluteus medius	External surface of the ilium, between the anterior and superior Gluteal lines	Lateral surface of greater trochanter of the femur.	Abducts and medially rotates thigh
○ Gluteus minimus	External surface of the ilium, between the anterior and inferior Gluteal lines	Anterior surface of the greater trochanter of the femur.	Abducts and medially rotates thigh
Hamstring ○ Semitendinosus	Ischial tuberosity	Medial surface of the superior part of the tibia	Extends thigh; flexes leg and rotates it medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
○ Semimembranosus	Ischial tuberosity	Posterior part of the medial tibial condyle,	Extends thigh; flexes leg and rotates it

		lateral to the femoral condyle	medially when the knee is flexed. When the thigh and knee are flexed, these muscles can extend the trunk.
◦ Biceps Femoris	Long head: Ischial tuberosity Short head: linea aspera and lateral supracondylar line of the femur	Lateral aspect of the fibula head. The tendon splits at this site by the fibular collateral ligament of the knee	Flexes the leg and rotates it laterally when the knee is flexed. Extends the thigh

Based on the discussion of all the strokes it can be seen that they all utilise a common set of muscles (Table 4.1 to Table 4.4) which undergo to varying degrees elements of repetitive motion in order to propel the swimmer through the water against the resistance and/or drag of the water, their body or any equipment that may be utilised (Stocker, D; Pink, M. and Jobe, F.W. 1995; McMaster and Troup, 1993; Johnson *et al.*, 1987). These factors cause a unique situation whereby the swimmer is at risk of developing various fatigue related injuries, better known as repetitive strain injuries (Banks, K.P; Ly, J.Q; Beall, D.B; Grayson, D.E; Bancroft, L.W; Tall, M.A, 2005; Shamus and Shamus, 2001; Rodeo, 1999). Overuse or repetitive strain injuries can be defined as a long-standing or recurrent musculoskeletal problem or one that is unrelated to an acute inciting event. It is a very common cause of pain in athletes (Banks *et al.*, 2005). In order to understand these better, possible mechanisms of these repetitive strain injuries will now be discussed.

2.5 Mechanism of Injuries

Swimming Injuries are predominately overuse injuries, with the shoulder being the most commonly affected joint. Cumulative, microtrauma resulting in tissue damage and ultimately overuse injuries (Shamus and Shamus, 2001). Elite swimmers train between 5 and 6 days a week, swimming an average distance of 8 000 to 20 000 metres per day, thus placing a swimmer at risk of repetitive strain injuries. A swimmer can swim up to approximately 35 000 to 40 000 arm strokes per week (Jones, 1999). Thus indicating the highly repetitive nature of swimming (irrespective of the swimming stroke), putting the shoulder

joint through its extremes of range of motion, while generating strong muscle contractions (refer to Tables 4.1 to 4.4) to sustain the forward propulsion (Moore and Dalley, 1999; Johnson *et al.*, 1987).

However, repetitive strain injuries may also occur as a result of specific technique within a particular swimming stroke. For example the flutter kick in Freestyle and Backstroke, causes repetitive quadriceps contractions (Tables 4.2 and 4.4) which may cause knee pain because of the accumulative patellofemoral overload (Rodeo, 1999).

Further compounding the repetitive strain on the musculature are factors related to the swimmer (intrinsic) and factors related to environment in which the swimmer trains (extrinsic).

2.6 Risk Factors for Injuries

There are several factors that influence a swimmer's performance and predisposition to injury, including intrinsic and extrinsic factors (Shamus and Shamus, 2001).

According to a study by O'Donnell, C.J; Bowen, J. and Fossati, J. (2005) shoulder pain in swimmer's is as a result of a number of contributing factors including, the swimmers gender, swimming experience, training distance, workout intensity, stroke choice, upper extremity weight training, stretching and the use of hand paddles (O'Donnell *et al.*, 2005). These factors could play a role in the development of injuries other than shoulder pain; however no data currently exists for injuries other than the shoulder (O'Donnell *et al.*, 2005), unless otherwise indicated in the literature review below.

2.6.1 Intrinsic Factors

Intrinsic risk factors relate to the individual participating in the sport and their individual physical and psychological characteristics (Lysens, R.J; de Weerdt, W and Nieuwboer, A. 1991).

Age of the swimmer tends to vary between 9 and 41.5 years (Capaci, K; Ozcaldiran, B. and Durmaz, 2002; Richardson, 1999; Pieper and Schulte, 1996; Stocker *et al.*, 1995), with an increase in age having been found to be statistically significantly associated with the clinical presentation of pain (Capaci *et al.*, 2002; Rodeo, 1999).

It has been anecdotally suggested that physiological characteristics of the swimmer have an effect on muscle endurance. As muscle endurance is an important factor in a swimmers performance, any limitation based on the swimmers physiological characteristics may hinder improvement in their performance (Shamus and Shamus, 2001). Therefore, endurance training is essential in decreasing muscle fatigue. Both land training and swimming training must include aerobic and anaerobic muscle conditioning in order to maximise the individuals swimming performance.

In addition to the above, rest and recuperation between sessions is very important in not only avoiding muscle fatigue, but also allowing for the normalisation of physiological mechanisms to decrease their affect on the swimmers performance. Thus swimmers would rather be prescribed "relative rest", however swimmers are reluctant to stop training completely as deconditioning occurs quickly. This is supported by the fact that even a short period of no training significantly decreases the swimmers muscle strength and endurance (Grote *et al.*, 2004). Therefore a swimmer with an upper limb injury may continue to train by only kicking with a kick board with or without fins. Whereas, a swimmer with an injury of the lower limb may only be able pull using a pull buoy (Jones, 1999). However each of these scenarios places increase stress on the functional musculature as well as that musculature

protecting the injured area increasing the likelihood of injury in one or both of these areas (Pieper and Schulte, 1996).

An illustration of the above two processes of a swimmer presenting with muscle weakness or muscle imbalances or poor flexibility has been shown may predispose the swimmer to injury (Shamus and Shamus, 2001). This is supported by Pieper and Schulte (1996) who found a correlation between muscle imbalances and chronic musculoskeletal injuries in elite swimmers. Swimmers that presented with clinical symptoms were found to have muscle imbalances on orthopaedic examination (Pieper and Schulte, 1996).

In addition to the physiological characteristics inherent to swimming, swimmers are also described as having poor posture. They are generally broad-shouldered athletes with a hyperkyphosis, hyperlordosis and recurvaturm body habit (Ferrell, 1999). These musculoskeletal changes have been associated with muscle imbalances (Pieper and Schulte, 1996). An example of this is seen in the lumbar spine, where a hyperlordosis will place increased pressure on the lumbar spine and in combination with poor swimming techniques, overtraining, the incorrect use of training equipment may result in the development of chronic lower back pain (Pieper and Schulte, 1996).

Further to the above, incorrect technique or errors in the stroke biomechanics may also predispose a swimmer to injury (Shamus and Shamus, 2001). Poor technique is an important factor in the development of overuse injuries (Capaci *et al.*, 2002). By correcting incorrect swimming technique will aid in the treatment of overuse injuries (Jones, 1999). Poor technique due to fatigue or improper stroke technique results in increased drag on the swimmer and therefore additional stress is placed on the shoulder joint (O'Donnell *et al.*, 2005). Addressing this incorrect training technique is the responsibility of the coaches, both in identifying the errors in technique; however it is ultimately the swimmers responsibility to effect the changes. Modifying a swimmers technique and ensuring that they have the proper swimming technique greatly improves the swimmers ability to train intensely and remain injury free

(Kammer *et al.*, 1999). This is supported by Stocker *et al* (1995) who indicates other factors relating to injuries in swimmers include; the side to which the swimmer breathes, an increase in the swimmers training intensity or an increase in distance.

Another important element which is principally the swimmers responsibility is that of nutrition which is key in remaining injury free. Swimmers' like all other athletes require a well balanced diet with an adequate energy intake that meets the demands of their training for increased muscle expenditure and competition as well as normal daily activities (Ousley-Pahnke *et al.*, 2001). This should include a greater intake of food, namely carbohydrates, proteins and fats (Costill *et al.*, 1992).That allow for food to act as slow release energy to sustain muscle strength. Without a balanced diet muscle fatigue increases which can reduce a swimmers performance (Shamus and Shamus, 2001). Therefore, it can be seen that if a swimmer does not maintain his/ her dietary requirements at an adequate level the nett effect will produce a greater likelihood of injury.

Fat is the body's largest source of potential energy. The process of converting fat to energy is slow, as it is an aerobic process. Body fat contributes to energy levels during prolonged training sessions and long distances events (Costill *et al.*, 1992). Similarly, proteins are essential in a swimmers' diet, as the amino acids in the protein are important in the building and repairing of the bodies tissues (Costill *et al.*, 1992). In addition, carbohydrates are the primary source of energy in swimming (Costill *et al.*, 1992). The body relies on carbohydrates as an immediate source of energy. This is why carbohydrate supplements are recommended during intense training (Shamus and Shamus, 2001). Lack of appropriate nutritional support is therefore seen as a possible precursor to injury especially in periods where high demands are placed on the body (Costill *et al.*, 1992).

However, not all swimmers may have access to the range of nutritional requirements and/ or supplementation. Furthermore, swimmers that may have

access to the nutritional requirements and supplementations are not obliged to utilise these optimally. Irrespective of the self imposed or external factors of not eating a well balanced diet, can result in muscle fatigue and injury presentation in swimmers (Shamus and Shamus, 2001).

2.6.2 Extrinsic Factors

Extrinsic risk factors relate to the type of sport the participant is involved in; their training regime; the equipment they use as well as the environmental conditions the participant is exposed to (Lysens *et al.*, 1991).Training regimes; include poorly planned and executed training programmes, poor stoke biomechanics; swimming too many races or galas or swimming the wrong events as well as the incorrect use of hand paddles and kickboards or other training aids (McMaster and Troup 1993; Kammer *et al.*, 1999; Shamus and Shamus, 2001). According to Rodeo (1999) an increase in the volume of training (distance swum) and the number of hours of training, as well as the calibre of swimmer, are all factors associated with the development of injuries. The cumulative effects of these extrinsic factors have been associated with competitive swimming careers of between 8 and 15 years predisposing the swimmers to injuries (Capaci *et al.*, 2002; Stocker *et al.*, 1995; Johnson *et al.*, 1987).

Hand paddles are used to strengthen the shoulder muscles and accentuate the feel of the water, by increasing the proprioceptive input (Jones, 1999). The use of hand paddles as well as training Butterfly places the swimmer in a position of hyperlordosis which may result in segmental instability of the lumbar spine and chronic lower back pain (Pieper and Schulte, 1996). Hand paddles have been identified as a major contributor to shoulder pain in swimmers. The additional strain that the hand paddles place on the shoulder may increase muscle fatigue which places the already susceptible shoulder at a high risk of injury (Johnson *et al.*, 1987).

The use of a kick board has been shown to aggravated the shoulder pain, as the shoulder is in a forward flexed and adducted position relative to the board (McMaster and Troup, 1993). If the kickboard is held in front of the swimmer's shoulders with the arms resting on the kickboard, it places the shoulder in a position that may recreate the "impingement position" and so aggravate shoulder pain (Jones, 1999).

To support the above, a questionnaire study by McMaster and Troup (1993), indicated a number of factors identified as potential aggravators of shoulder pain. These factors included the use of hand paddles and kick boards during training. In addition, weight training and stretching as well as the swimmer's experience or duration of time the swimmer has been involved in the sport were also identified (McMaster and Troup, 1993).

2.7 Swimming Injuries

Swimming injuries are predominately caused by the repetitive overuse of certain muscles, with the shoulder being the most commonly affected joint. In a study by McMaster and Troup (1993), on 1262 competitive swimmers in the United States, they found 47% of 13-14 year old swimmers, 66% of 15 -16 year old swimmers and 73% of elite swimmers had a history of shoulder pain.

Knee pain has been ranked as the second most common injury attained by swimmers, with the most commonly injured area being the shoulder (Rodeo, 1999). Knee pain has been reported to be most common in Breaststroke swimmers, although it has been identified in the other strokes, namely Freestyle, Backstroke and Butterfly (Rodeo, 1999). In a study by Rovere and Nichols (1985), found 75% of Breaststroke swimmers experienced at least three episodes of unilateral or bilateral knee pain in a season.

Competitive swimmers have a relatively low incidence of back pain (Ferrell, 1999). According to Ferrell (1999), Butterfly and Backstroke swimmers are

most prone to lower and middle back pain, especially at the thoracolumbar junction.

2.8 Injuries Associated with Swimming

Competitive swimmers perform highly repetitive movements of their upper and lower limbs. This results in overuse injuries occurring at the shoulder, knee and back. Such overuse injuries may be as a result of intrinsic factors such as muscle imbalances, weakness, fatigue and poor flexibility. Extrinsic factors, predominately poor technique may play a role in a swimmers risk of acquiring an injury (Capaci *et al.*, 2002). As a result of the above, several studies have been completed in order to more fully understand swimming injuries (Grote *et al.*, 2004; Shamus and Shamus, 2001; Kammer *et al.*, 1999; Rodeo, 1999; Johnson *et al.*, 1987). These will be discussed in the next section.

2.9 Anatomical Location of Injuries

2.9.1 Upper Extremities

2.9.1.1 Shoulder

Shoulder injuries are the most common musculoskeletal complaint in competitive swimmers (Johnson *et al.*, 1987). Shoulder injuries are largely as a result of long-term overuse and repetitive microtrauma (Kammer *et al.*, 1999). The majority of propulsion in swimming is generated by the swimmers arm pull. Maximal propulsive forces are applied to the upper extremity as it moves through an extreme range of motion (Shamus and Shamus, 2001).

"Swimmers shoulder" is the most common overuse injury in swimming and involves inflammation of the supraspinatus and biceps tendons with possible glenohumeral instability (Kammer *et al.*, 1999). Johnson *et al.*, (1987) indicate that shoulder pain is more prevalent in Freestyle, Backstroke and Butterfly as

these strokes have a wide arc of shoulder circumduction, while in Breaststroke, studies show that swimmers are rarely afflicted with shoulder pain as there shoulders are involved in much less abduction (Johnson *et al.*, 1987).

2.9.1.2 Elbow

Elbow injuries in swimming are generally a result of repetitive overuse and incorrect swimming techniques. Swimmers are encouraged to swim with a high elbow position during the pull phase in Freestyle. This predisposes the swimmers to increased stress on the medial collateral ligament of the elbow (Kammer *et al.*, 1999).

However, by dropping the elbow in the pull through phase it will decrease the efficiency of the stroke and thus increase the stress on the shoulder joint (Kammer *et al.*, 1999).

The most common elbow injuries in swimmers are triceps strain and synovitis. These generally occur due to the elbow being forced into full extension during Backstroke (Kammer *et al.*, 1999). A triceps strain will present as pain on resisted contraction of the triceps muscle (Shamus and Shamus, 2001).

2.9.2 Lower Extremities

2.9.2.1 Hip

Breaststroke and Individual Medley (IM) swimmers commonly experience hip or groin pain due to the repetitive stress on the hip adductor muscles during training and competition. The most stress occurs at the end of the powerful kick, when the hip is forced into adduction while the knees are flexed and the feet and ankles are externally rotated (Grote *et al.*, 2004).
Breaststroke swimmers are more at risk then IM swimmers as their training involves a higher percentage of Breaststroke swimming. Hip adductor injuries

are seen to be a direct result of an increased distance of Breaststroke training (Grote *et al.*, 2004).

2.9.2.2 Knee

The knee is the most commonly injured area of the lower extremity in some swimmers. Most knee pain is felt on the medial aspect of the knee. Knee injuries can occur in any of the four swimming strokes but is commonly experienced by Breaststroke swimmers. Knee injures and pain is predominately as a result of repetitive overuse (Rodeo, 1999).

"Breaststroker's knee", as it is commonly referred to, is a chronic Medial Collateral ligament (MCL) sprain. This is due to the repetitive stress placed on the MCL as a result of the forced whip kick used in Breaststroke (Shamus and Shamus, 2001). In the Breaststroke kick there is a high valgus load on the knee as the knee is rapidly extended, thus causing a large amount of stress on the medial aspect of the knee, as well as a compressive stress on the lateral aspect of the knee (Rodeo, 1999).

Knee injuries can also occur as a result of the repetitive contraction of the quadriceps muscles during the flutter kick in Freestyle and Backstroke, causing a repetitive overload on the patellofemoral joint (Rodeo, 1999). A high amount of stress is also placed on the patellofemoral joint as the swimmer pushes-off from the wall due to the forceful contraction of the quadriceps while the knee is in a high degree of flexion (Rodeo, 1999).

2.9.2.3 Foot and ankle

A large degree of plantarflexion is required during swimming as it places the foot in a better position during the propulsive phase of the flutter and dolphin kick (Johnson *et al.*, 1987). A greater degree of ankle flexibility, especially in dorsiflexion is required by Breaststroke swimmers. This allows the Breaststroke swimmer to place their feet in a better position to push the water

backwards earlier in the stroke. According to Johnson *et al* (1987), this enables a more effective kick. The repetitive motion of whip, flutter and dolphin kicks experienced by swimmers may result in tendonitis of the extensor tendons of the foot and ankle (Johnson *et al.*, 1987). Although tendonitis of the foot and ankle is not reported to be as common as shoulder or knee injuries, it still may considerably affect a swimmers performance (Johnson *et al.*, 1987).
Mild ankle sprains and foot contusions also occur, although they are rare, and are generally as a result of improper flip- turns (Kammer *et al.*, 1999).

2.10 Conclusion

As can be seen from the review of the literature there are a variety causes for musculoskeletal injuries in swimmers. These injuries may result from intrinsic (demographics of the swimmer as well as factors determined by the swimmer) or extrinsic factors (swimming history, injury history and factors associated with their training environment).

As no studies have been found regarding the profile of musculoskeletal injuries in competitive swimmers in South Africa, or with particular reference to the greater Durban area. Thus the aim of this study was to determine a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa. In addition this study set out to determine whether any relationships exist between risk factors identified in other studies and swimming injuries highlighted in this study, and to compare these results with international data.

Chapter 3

Material and Methods

This chapter will discuss the research methodology and data collection used in this study. Statistical analysis will also be discussed.

3.1 Study Design

This study was a prospective, cross-sectional, questionnaire investigation to determine the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area.

The data was collected by means of a self-administrated (Salant and Dillman, 1994) questionnaire (Appendix L), which was completed by the participants, under the supervision of the researcher, parents or coach.

No advertising was required for this study.

3.2 Allocation of the participants

3.2.1 Sampling

A total sample method was used (Esterhuizen, 2007), as the entire population of competitive swimmers registered with the KwaZulu Natal (KZN) Aquatics association, residing in the greater Durban area were invited to participate in the study. Sample stratification by region or any other variable was not considered for this study in order to negate the effects of stratification on injury point prevalence and incidence (Babbie, 1998).

3.2.2 Sample Size

The entire population of competitive swimmers registered with KZN Aquatics Associations were invited to participate in the study. This population size included four hundred (N= 400) swimmers between 10 and 30 years of age (KZN Aquatics, 2007).

The response rate required prior to statistical analysis was defined as a minimum response rate of 25%, thus a sample of one hundred (n= 100) competitive swimmers was required to make this study's statistics generalisable to the population (Esterhuizen, 2007). In a similar study on gymnasts by Adamson (2006), a minimum response rate of 16% was required, which still yielded statistically valid data.

3.3 Criteria for Participation in the Study

3.3.1 Permission required for the study

3.3.1.1 Location

Permission to conduct the research process was obtained from the Ethekwini Municipality or owner of the swimming pools, prior to the commencement of the study. The Ethekwini Municipality or owner of the swimming pool was requested to sign a Letter of Permission (Appendix Q) prior to the start of the study. A copy of the signed permission letter was required form the Faculty of Health Sciences Research and Ethics Review Board prior to approval of the study.

3.3.1.2 Coaches

Coaches of each of the swimming clubs in the greater Durban area were contacted, either in person or telephonically and permission was obtained to conducted research at their respective clubs. The Letter of Permission (Appendix P) was signed prior to the swimmers having been spoken to. This approval was not required for Faculty of Health Sciences Research and Ethics Review Board, but was required as part of the study design.

3.3.1.3 Participants and where applicable participants parents

Each participant was required to read a letter of Information (Appendix M) and sign a letter of Consent/ Assent (Appendix N) and a Consent/ Assent form (with the parents signing the consent form) (Appendix O). By signing the Consent / Assent forms the participant acknowledged the terms and conditions of the research process.

In line with the design of this study and according to the Nuremberg code (1947): cited in Alderson (2007) consent is defined as; "The voluntary consent of the human subject is absolutely essential. This means that the person involved should be situated as to be able to exercise free power of choice, without the intervention of any elements of force, fraud, deceit, duress, overreaching, or ulterior form of constraint or coercion."

According to the Declaration of Helsinki (1975), consent from the minor's parent or legal guardian must be obtained in addition to the minor's consent. Assent from a child must be attained from the age of 7 years upwards (Alderson, 2007). According to Royal Collage of Physicians (1990), cited in Alderson (2007) it is unacceptable not to attain consent from the parent or legal guardian of a child under the age of 18 years.

3.3.2 Inclusion Criteria

The inclusion criteria for the participants were as follows:

- Participants had to have resided in the KwaZulu-Natal province, principally in the greater Durban area.
- Participants were required to be competitive swimmers, defined as participants having competed in:
  - A minimum of 3 minor qualifying events (these included age group galas and Natal Championships or any other equivalent event) and / or
    - 1 National event or
    - 1 International event,
  - And / or a combination of the above.
- Participants had to be between the ages of 10 and 30 years of age. (KZN Aquatics)
- Participants were required to fill in the Consent/ Assent form (Appendix O) and a letter of Consent/ Assent (Appendix N), therefore providing an informed decision to participate in the study. Parental consent was obtained for participants under the age of 18 years (Alderson, 2007).
- The participant had to be at least second language English speaking. The reason for this is that the instructions were issued in English, as concurrent validity of the questionnaire had not been completed in another language. According to Scollen and Scollen (1995), even if words are translated accurately, the meaning of a phrase or combination of words may become unclear.

3.3.3 Exclusion Criteria

The exclusion criteria for the participants were as follows:

- Participants who did not correctly complete and sign the Consent / Assent form (Appendix O) and the Letter of Consent / Assent (Appendix N) were excluded from the study.
- If parental assent was not obtained for participants under the age of 18 years, they were excluded from the study.

3.4 Ethical Considerations

Access to the questionnaire was limited to the researcher and the researcher's supervisor.

The questionnaires were numbered and the data coded, thus ensuring participant anonymity. Salant and Dillman (1994), define anonymous as meaning that individual people cannot be associated with specific questionnaires.

Confidentiality is defined as meaning that one is not able to associate individual people with specific questionnaires responses (Salant and Dillman, 1994).

In respect of all ethical considerations this proposal was passed and approved by the Faculty of Health Sciences Research and Ethics Committee at the Durban University of Technology, indicating that this research complied with the Declaration of Helsinki (1975).

3.5 Data Collection Procedure

Once permission was received from the Ethekwini Municipality or owner of the swimming pools, the researcher contacted the swimming coaches to inform them of the study and obtain their permission to carry out the research at their swimming clubs (as per section 3.3.1.1 discussed above).

Once permission was received from the swimming coaches, the researcher approached all the swimmers at the relevant swimming clubs, and informed them of the study (as per section 3.3.1.2 discussed above).

The researcher also distributed a Letter of Information (Appendix M), and Consent/Assent Form (Appendix O) and a Letter of Consent/ Assent (Appendix N) to the prospective participants to complete. Participants meeting the criteria for inclusion in the study received a questionnaire to complete.

The questionnaires were handed out in a semi-supervised manner, in a group environment. The participants all received the same instructions and questions or queries were handled in a similar manner.

Participant's filled out the questionnaire with respect to:

- Participant's demographics including age, gender, ethnic group and type of stroke they swum and preferred distance at which they compete.
- Information on the participant's swimming history, including the number of years experience, number of hours of swimming training and land training per week, distance per week and number of swimming sessions they attended per week.
- Information on the participant's involvement in other sports and injuries obtained during these activities.
- Factors relating to the injuries:
    - Location of past and current injuries;

- Length of time for which the past and current injuries have been present;
- Effect of past and current injuries on swimming training and competitions;
- Length of time for which swimming was prevented as a result of these injuries;
- Mechanism of current injury;
- Severity of current injury and
- Treatment received for past or current injuries

- Other Factors related to injuries:
  - Eating habits and supplementation;
  - Additional recreational and/ or competitive activities and
  - Regular maintenance treatment and/ or stroke correction to improve performance.

The data collected from each questionnaire was then used for data capturing purposes. An analysis was performed to determine the musculoskeletal injury profile of competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa.

3.6 Development of the Questionnaire

3.6.1 The Initial Questionnaire

The questionnaire was developed by using an existing questionnaire (Appendix A2) designed by Adamson (2006) for gymnasts. A letter of Permission (Appendix A1) from Adamson was obtained prior to commencing the study, allowing the researcher to utilize The Gymnastics Injury Questionnaire. By using an existing questionnaire, construct validity was incurred (Bernard, 2000).

Parameters in studies by Rover (1985), McMaster and Troup (1993), Veni *et al.*, (1999); and Johnson *et al.*, (1987) were also used to aid in the

development of The Competitive Swimmers Injury Questionnaire (CSIQ). In addition the Gymnastic Injury Questionnaire (appendix A2) was converted into one that was relevant for competitive swimmers.

A number of parameters included in The CSIQ were as a result of recommendations from the Focus Group (see section 3.6.2, pg 55).

The CSIQ was then validated, by means of a focus group and a pilot study. These processes where used to confer validity, where validity refers to establishing the accuracy and trustworthiness of an instrument, data and findings in the research thereby ensuring that future research utilizing that particular tool is accurate (Bernard, 2000).

In order to understand the processes utilised in this study, it is imperative to understand the different types of validity. Validity in questionnaire based research can be divided into face validity, content validity, construct validity and criterion validity (Mouton, 1996), where:

Face validity: this is the simplest type of validity, which determined by the agreement between the researcher and those with an interest in the questionnaire (Bernard, 2000). Thus at 'face value' the questionnaire appears valid, unambiguous and easy to interpret by a lay person.

Content validity: an instrument has content validity when the content of the questionnaire is considered to be effective, and appropriate enough to be able to assess a particular concept (Bernard, 2000).

Construct validity: measures the degree of closeness between the construct being measured and the actual observation made with the instrument, how accurately answers to the questions in a

scale of reflected theoretical prediction of a particular construct (Bernard, 2000).

Criterion validity: is measured when a particular tool produces similar results when compared with another tool already known to be trustworthy. This is also referred to as concurrent validity by Mouton (1996).

In order to achieve these validities, a focus group and pilot study where completed, which are discussed below.

3.6.2 The Focus Group

This was achieved by having a Focus Group representative with specific areas of expertise related to the research being conducted as well as the respondent representation. The Focus Group was conducted, in order to attain face validity and content validity (Bernard, 2000)

A Focus Group provides a means of interaction and discussion between the researcher and individuals with a vested interest in the topic. It also provokes the development of ideas and understanding on the topic (Morgan, 1998). A focus group also aids the researcher in finding and accessing the relevance and appropriateness of the questions used in the development of the questionnaire (Morgan, 1998). As well as modifying the questions. Furthermore increase the questionnaires Face Validity.

According to the Morgan (1998) a focus group should consist of 6 – 8 participants. These participants are selected because of there similarities to the participants that will ultimately complete the questionnaire with regards to knowledge, age and possible language barriers (Fink and Kosecoff, 1985; Morgan, 1998) as well as swimmers who have an interest in the outcome to the study.

In this focus group participants were enlisted via word of mouth, with seven participants coming forward and expressing an interest in participating in the focus group. The group consisted of one swimming coaches, two competitive swimmers, three healthcare professionals and the researcher (myself).

Before commencing the focus group, each participant was required to read the Letter of Information (Appendix B) and sign an Informed Consent Form (Appendix C) as well as a Code of Conduct (Appendix D) and a Confidentiality Agreement (Appendix E). In the Focus Group each participant was given a copy of the CSIQ (Appendix A3).

Comments were requested from each of the participants on how the questionnaire could be modified and improved so that it could be used to accurately access competitive swimmers injuries in the context of this study, the CSIQ was discussed to determine the accuracy of the content relating to swimming injuries.

The questions were discussed in numerical order. If there were any queries or changes proposed the question was discussed until an agreement was reached. At the end of the discussion, time was given for any further comments on the questionnaire. A video of the Focus Group was made and is available as evidence of the individuals involved and the content of the discussion. A transcript of the proceedings is available (Appendix F).

Suggestions for changes were taken into account, and relevant changes were made to the questionnaire. The result of which is used in the study yielding the version used in this study (Appendix L).

The participant's discussion from the Focus Group was kept confidential. This was ensured as each member of the focus group was made to sign a Confidentiality agreement (Appendix E). The transcripts (Appendix F), documents and video tape from the proceedings will remain in a secure area

in the researcher's administration office and after a period of five years will be shredded.

Therefore, the Focus Group was conducted to attain face validity, content validity (Bernard, 2000) for the purposes of data collection in this study.

3.6.2.1 Focus group discussion.

A number of changes to the questionnaire were suggested by the Focus Group. This included adding or deleting, correcting spelling and grammar and changing the wording of the questions to make them less ambiguous was done.

The CSIQ was increased in length from 36 questions to 57 questions.
The questionnaire was given a title, a numbering system and the title of the study was added to the top of the questionnaire.

Section 1:

With respect to the patient Information it was suggested that instead of asking the patient's sex, it was changed to the gender of the patient.

The original question pertaining to exercise was separated into two questions.

Question 4; 5 and 6 asked about exercise (e.g. gym, weight training), the worst injury you sustained due to this exercise and if it prevented the participant from swimming.

Question 7; 8 and 9 pertained to other sports that participants may compete in (e.g. waterpolo and rugby) and injuries if any sustained from these sports and if these injuries prevented the participant from swimming.

A list of supplements was included in the study. As well as questions about hereditary diseases.

Section 2:

Swimming history questions regarding the average duration of each swimming session, the rest time between sessions, the number of sessions swam per week and the swimmer's stretching habits were included; as well as questions pertaining to the events and galas that a swimmer could compete in. Questions regarding stroke correction, how they breathe; the types of equipment they use were added. In addition to this it was asked whether or not they received maintenance interventions for injuries, if so what type of treatment do they receive.

Section 3:

In the section pertaining to previous swimming injuries a number of questions were added and removed. Questions 19, 20, 26, were removed from this section. For question 18, a table was added for clarity and columns were inserted to indicate the type of injury i.e. traumatic.

Participants were asked to name their past injuries and describe how they occurred. Participants were asked to specify the area of the body that was injured due to swimming as well as if the injury limited there swimming training. In question 27, it was what the longest period was that the participants were unable to swim for. An extra column stating less than 1 month was added. Questions regarding the most likely cause of the injury and the activity (swimming and other sports participated in) during which the injury was sustained were also included.

The tables were modified for clarity.

Section 4:

This section focussed on any current swimming injuries. Question 29 was removed from this section. Questions regarding the type of injury the participants have and treatment received for that injury were added to this section.

In this section it was suggested that they participants name their current injury, with a maximum of 3 injuries allowed to be listed. The remaining portion of this section was only relevant to the most severe of the three injuries listed. Furthermore, participants were also asked during which part of their swimming cycle their injury had occurred.

Tables were also modified for clarity.

The Focus Group was very beneficial in the development of the CSIQ.

3.6.3 The Pilot Study

A Pilot Study followed the Focus Group. This procedure included three participants that completed the questionnaire (Appendix G) as though they were responding to the actual questionnaire. After the completion of the questionnaire the Pilot Participants completed a pre-research questionnaire evaluation sheet (Appendix K) which isolated problems/ errors or omissions with respect to grammar, sentence structure, ease of answering the questions and clarity of instructions, ambiguity as well as problems relating to logisitics (e.g. time).

According to Fink and Kosecoff (1985) the purpose of a pilot study is to answer the following questions

- Will the questionnaire provide the necessary information?
- Are certain questions in the questionnaire redundant or misleading?
- Are the questions appropriate for the individuals who will be participating in the survey?
- Will the information that the researcher collects enable him to use the survey forms properly?
- Are the procedures standardized?
- How consistent is the information obtained by the survey
- How accurate is the information obtained by the survey

A Pilot Study was completed to verify construct validity of the questionnaire, where construct validity measures the degree of closeness between the construct being measured and the actual observation made with the instrument, how accurately answers to questions in a scale of reflected theoretical predictions of a particular construct (Bernard, 2000).

No changes were made to these pre-research questionnaires (Appendix G).

3.6.4 The final questionnaire

The CSIQ is a fully quantitative questionnaire (Appendix L).
The CSIQ is divided into four sections the Patient Demographics, Patients Swimming History, Previous swimming injuries and Current swimming injuries.

Section one the Patient Demographics included questions pertaining to the swimmers age, gender, and ethnic group, involvement in other exercises or sporting activities and any injuries pertaining to these activities. Dietary and the use of supplementation are also included in this section, as well as questions pertaining to a family history of musculoskeletal diseases.

Section two the Patients Swimming History included questions pertaining to the swimmers involvement in the sport of swimming. The age at which the participant started swimming competitively, the number of years the participant has swam competitively. It also included questions regarding their training schedule i.e. the number of hours the participant swims per week, the number of session the participant attends per week, the duration of each swimming session, the distance swum per week, the amount of rest they have between each swimming session. This section also referred to their classification. So questions pertaining to the level of competition at which they compete and information regarding their participation in galas were asked, furthermore questions referring to the swimmer's dry land training, their

stretching habits, the equipment they use during swimming training and whether the received stroke correction were asked.

Section three and four the patients 'Previous Swimming injuries and Current Swimming injuries'. These two sections included questions pertaining to the swimmers previous and current injuries as well as the treatment that they may have received for their injury.

3.7 Frequency of administration of the Questionnaire

The Competitive Swimmers Injury Questionnaire was administered once per participant.

3.8 Statistical Analysis

Data was analysed using SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). A p value of <0.05 was considered as statistically significant.

Descriptive analysis for categorical variables was by means of frequency tables and bar charts, and for quantitative variables summary statistics were generated to identify mean, standard deviation and range.

Hypothesis testing was used to assess associations between risk factors (patient demographics, swimming history, past or current injuries and intrinsic and extrinsic factors) and ever having a swimming injury. Quantitative variables were compared using t-tests and categorical variables were compared using Pearson's chi square tests or Fisher's exact tests as appropriate (Bivariate analysis). In order to determine the independent risk factors associated with injury, logistic regression analysis was used (multivariate analysis). All risk factors significantly associated with injury on bivariate analysis were entered into the model and a backwards elimination technique was used using likelihood ratios to arrive at a final model.

An attempt was made to identify the potential risk factors that existed in the participants in this study. If so, whether there were any significant relationships that existed between the risk factors and the swimming injuries present in this study. The results from the questionnaire were compared to available international data.

CHAPTER 4

Results

4.1 Introduction

This chapter reveals the results obtained from the statistical analysis of the data collected.

4.2 Outline of the Objectives of the Study

4.2.1 The First objective was to describe and summarize the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area, KwaZulu-Natal, South Africa with respect to questionnaire responses including an injury profile.

4.2.2 The Second objective was to identify the association between context factors (definition of the profile of musculoskeletal injuries pg xxii) and the report of the injuries.

4.3 Data

4.3.1 Primary data

In this study the primary data was collected using a self-administrated, prospective, cross- sectional questionnaire (Fink, 1995).

4.3.2 Secondary data

In this study secondary data was collected from the following sources: journal articles, books, through personal communication with relevant people, focus group and pilot study participants.

4.4 Abbreviations used in this Chapter

B - Beta Coefficient

CI – Confidence Interval

Df - Degrees of Freedom

N - Sample Size.

In this study n may vary as not all the participants in the study were injured and therefore the number of injured participants differs from the total number of participants who completed the questionnaire.

OR – Odds Ratio

p value - Probability value (if <0.05 then significant)

S.E. - Standard Error

Std. dev - Standard Deviation

wald - This is the test statistic from the Wald chi square test from which the p value in the logistic regression is generated.

4.5 Results

4.5.1 Response Rate for this Study

The sample consisted of the entire population of competitive swimmers registered with KZN Aquatics Associations which was four hundred (N= 400) swimmers between the ages of 10 and 30 years of age (KZN Aquatics, 2007). Questionnaires were given to each of the 400 swimmers.

A total of 116 questionnaires were returned, however 15 of the total returned questionnaires had to be excluded form the study as they did not meet the inclusion criteria. This is because the participant's didn't complete or sign the consent/ assent forms correctly and or parental consent was not attained for minors under the age of 18 years.

Therefore n= 101 questionnaires were used in the statistical analysis, making the response rate 25.25%. This met the requirement of a 25% response rate, set by the Faculty of Health Sciences Research and Ethics Committee (Chapter 3 section 3.2.2).

Not all the questions in the results added up to 101 due to the fact that if the participant's did not have an injury, the questions pertaining to the injury were not answered. Alternatively if the questions did not add up to 101 the answers were either irrelevant or unknown. If the questions added up to more than 101 it was due to the fact the participant had the option of selecting more than one answer.

4.5.2 Objective 1: To describe and summarize the profile of competitive swimmers in the greater Durban area, KwaZulu-Natal, South Africa with respect to questionnaire responses including an injury profile.

4.5.2.1 Demographics: Section 1 of the CSIQ

There were 101 participants that took part in the study.

4.5.2.1.1 Age (Q1 of the CSIQ)

Their ages ranged from 10 to 30 years, with a mean of 16.7 years and a standard deviation of 4.4 years.

Table 4.1: Summary statistics for age of participants (n=101)

	Mean	Standard Deviation	Minimum	Maximum
Age	16.7	4.4	10	30

4.5.2.1.2 Ethnic & Gender (Q2 and Q3 of CSIQ)

There were 50 males (49.5%) and 51 females (50.5%). Their ethnic group was mainly White (89.1%). A summary of this data is shown in Table 4.2.

Table 4.2: Frequency and percentage for gender and ethnic group in study participants (n=101)

		Count	Column N %
Gender	Male	50	49.5%
	Female	51	50.5%
Ethnic group	Black	1	1.0%
	White	90	89.1%
	Coloured	7	6.9%
	Asian	0	.0%
	Indian	3	3.0%
	Other	0	.0%

4.5.2.1.3 Diet, supplementation and hereditary disease history (Q10 – Q13 of CSIQ)

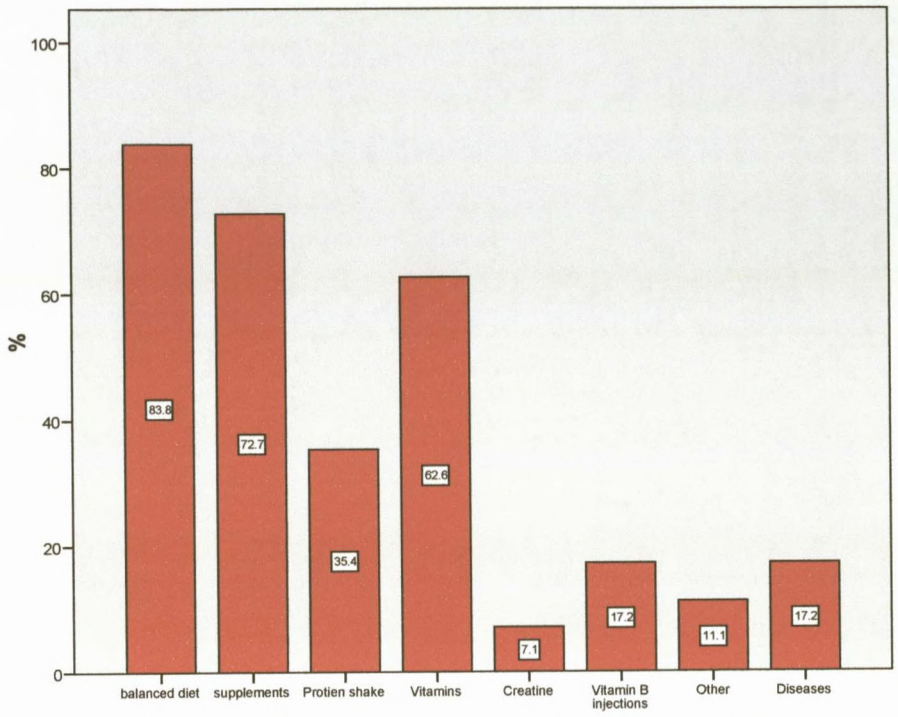

Figure 4.1: Percentage of "yes" responses to Diet, Supplementation and Hereditary Disease questions

Figure 4.1 Shows that 83.8% of participants felt they ate a balanced diet, 72.7% were taking supplements. The types of supplements taken were mainly vitamins (62.6%) and protein shakes (35.4%). For those who responded "other" the specified supplements are listed in Table 4.3.

Table 4.3: "Other" Supplements taken

	Frequency	Percent
Arthroguard	1	9.09
Carbohydrate drinks	1	9.09
Cytomax-training drink	1	9.09
Iron	1	9.09
Staminade	2	18.18
Staminade, l-glutamine	1	9.09
USN-zma	1	9.09
USN-zma, Phedro-cut	1	9.09
USN diet fuel	1	9.09
ZMA (for recovery)	1	9.09
Total	11	100.00

Eighteen participants reported having other diseases in their family. These are listed in Table 4.3.

Table 4.4: Specific diseases reported

	Frequency	Percent
Arthritis	8	44.44
Gout	1	5.56
Osgood Schlater's disease	1	5.56
Scheuermann's disease	1	5.56
Scoliosis	4	22.22
Scoliosis, arthritis	1	5.56
Sever's disease, Hyperflexibility	1	5.56
Spina bifida	1	5.56
Total	18	100.0

The onset of the lifetime incidence of injuries were mainly over a period of time (56.9% and 56.3% of first and second injuries respectively). This is shown in Table 4.4. It should be noted that the responses of Scoliosis and arthritis as well as Sever's disease and hyperflexibility were reported by individual participants who reported suffering from these conditions concurrently.

4.5.2.2. Swimming History: Section 2 of the CSIQ

4.5.2.2.1 **Swimming history** (Q14- Q22 and Q32 –Q33 of CSIQ)

Table 4.5 shows the mean, standard deviation and range of values for questions regarding swimming history.

Table 4.5: Summary statistics for swimming history of participants (n=101)

	Mean	Standard Deviation	Minimum	Maximum
Age started swimming	9.6	2.3	5	19
Number of years competing	6.7	4.3	1	20
Number of hours per week	11.1	4.9	2	25
Duration of each session (hours)	1.8	0.4	0.8	3.0
How many km swum per week	32.2	19.7	2.5	85.0
Number sessions per week	5.8	2.1	2	11
Number rest time between sessions (hours)	19.6	8.3	6	48
Hours of land training	2.9	2.1	0	10
Hours spent stretching	0.4	0.3	0.0	2.0
How many galas do you swim in a season?	8.9	4.2	2	25
Races per gala?	5.8	2.2	2	12

4.5.2.2.2 **Stretching history** (Q23 of CSIQ)

Figure 4.2 shows that just over half the participants stretched before exercise (52.53%), while 17.17% never stretched.

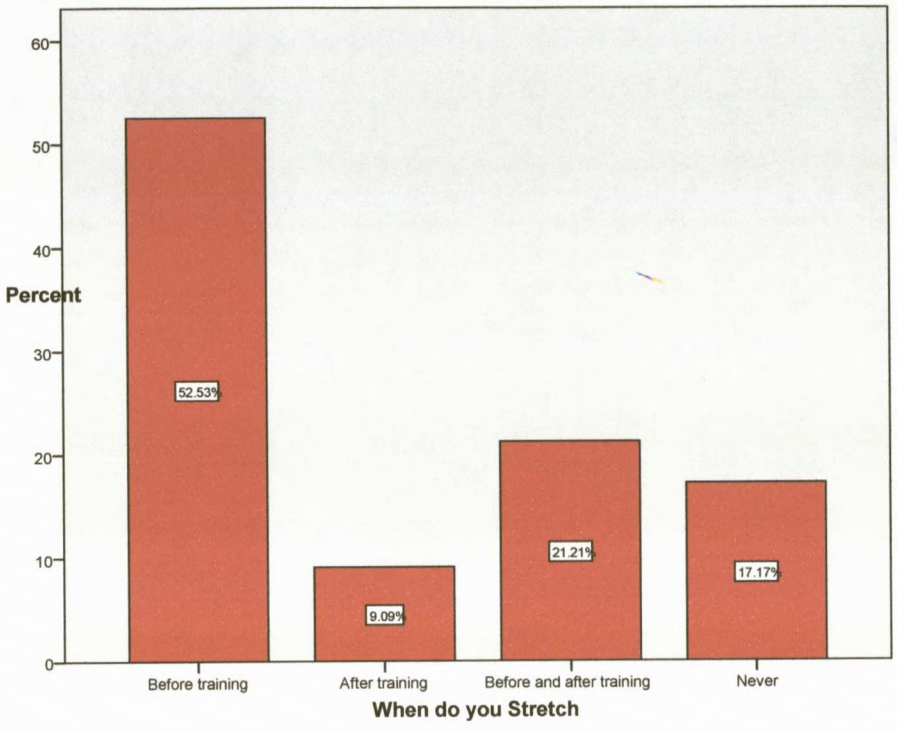

Figure 4.2: When stretching occurs

4.5.2.2.3. Stroke, distance and event history (Q24- Q29 of CSIQ)

Freestyle was the most common main stroke (n=39, 38.6%) and second main stroke (n=37, 36.6%). This is shown in Table 4.6.

Table 4.6: Main and second main stroke of participants (n=101)

	Butterfly		Backstroke		Breaststroke		Freestyle		Individual Medley	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Main Stroke	22	21.8%	17	16.8%	20	19.8%	39	38.6%	3	3.0%
Second Main Stroke	31	30.7%	15	14.9%	8	7.9%	37	36.6%	10	9.9%

Figure 4.3 show that the majority of participants considered themselves to be sprinters (78.2%). While 50.5% were middle distance swimmers, 8.9% long distance and 7.9% open water. The percentages do not add up to 100% as participants were allowed to classify themselves into more than one category.

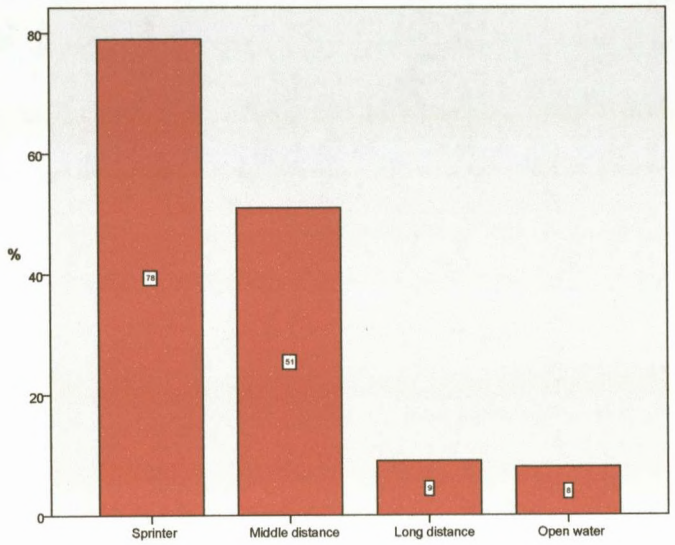

Figure 4.3: Type of Swimmer

Figures 4.4 to 4.9 show the number of participants who stated that each type of event was either their main event, secondary event or other event. The most popular main event was freestyle 100m, followed by freestyle 50m.

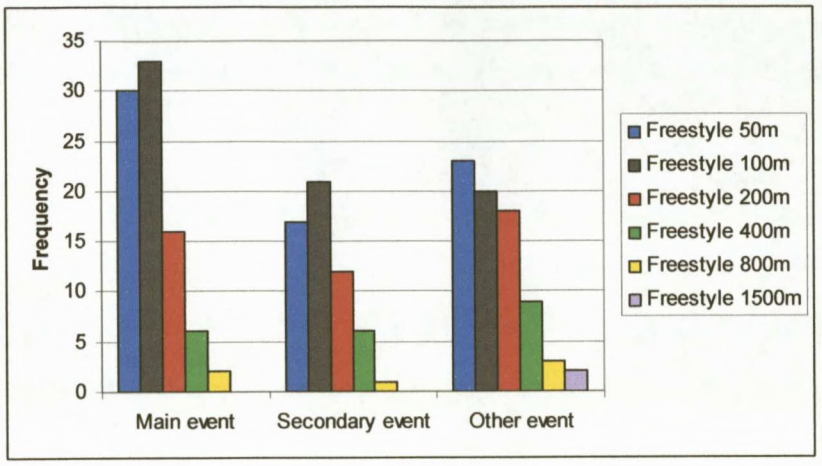

Figure 4.4: Freestyle

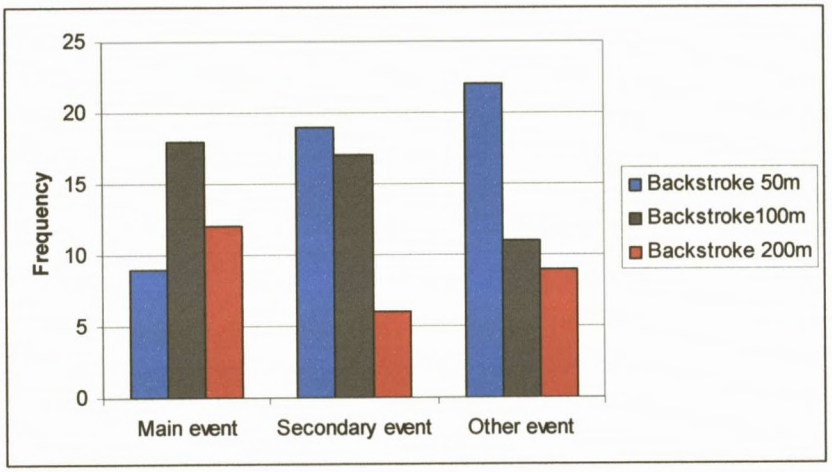

Figure 4.5: Backstroke

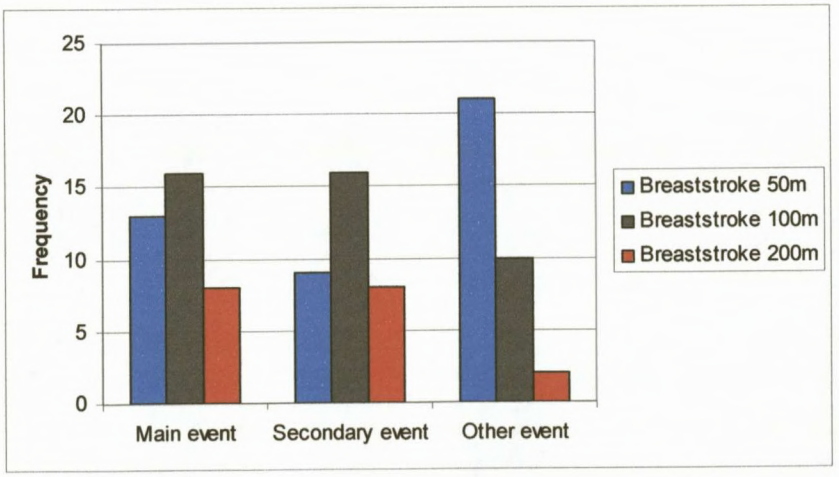

Figure 4.6: Breaststroke

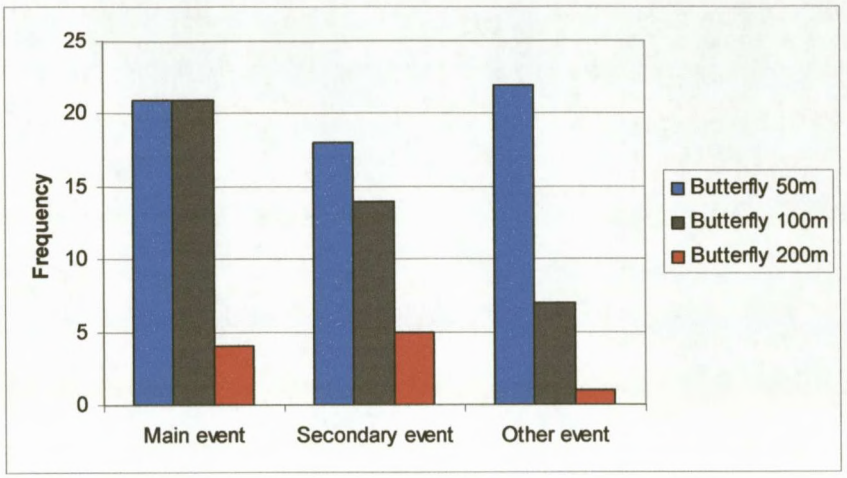

Figure 4.7: Butterfly

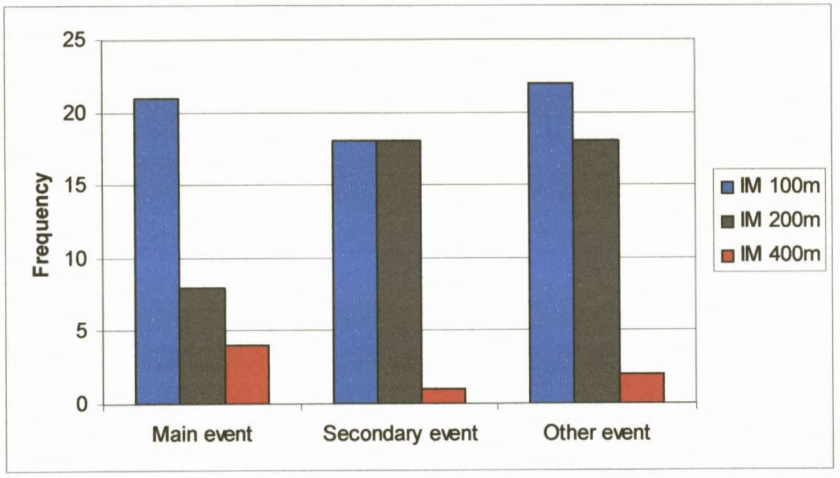

Figure 4.8: Individual Medley

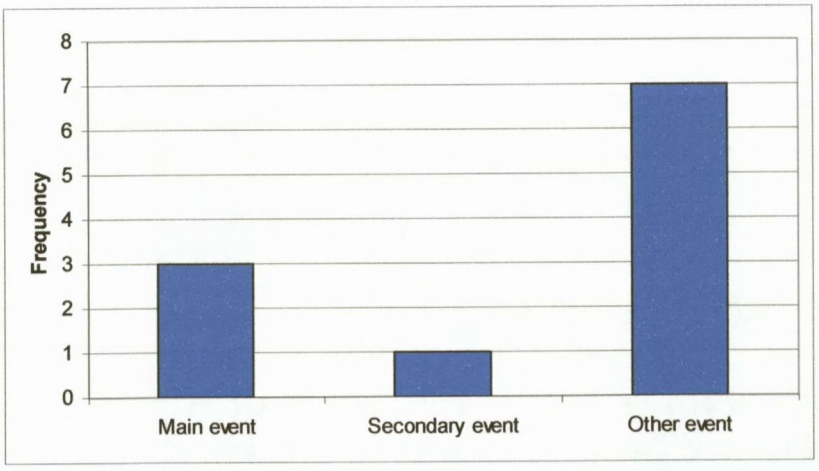

Figure 4.9: Open water

4.5.2.2.4 **Breathing Style** (Q30 of CSIQ)

The most common was to breathe from bilaterally sides (n=41, 40.6%). Similar numbers of participants breathed to either their left or to their right side. This is show in Table 4.7.

Table 4.7: Side to which participants breathe

	Frequency	Percent
Left	28	27.7
Right	32	31.7
Bilateral	41	40.6
Total	101	100.0

4.5.2.2.5 **Level of competition** (Q31 of CSIQ)

It can be seen from Figure 4.10 that the highest level of competition in the participants was mainly National level (38.6%). Similar numbers had competed at Provincial and International level, while the lowest percentage had only competed at schools level (12.87%).

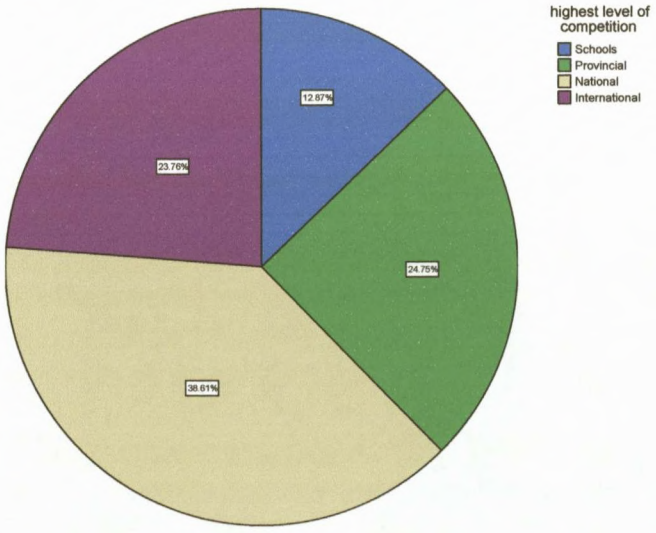

Figure 4.10: Highest level of competition (n=101)

4.5.2.2.6 Stroke Correction and the Equipment used (Q35 and Q36 of CSIQ)

The majority of participants (n=59, 58.4%) received regular stroke correction. There were various types of equipment used in training. The main ones being kick boards (87.1%) pull buoys and fins (80.2% each) and paddles (71.3%). This is shown in Figure 4.11.

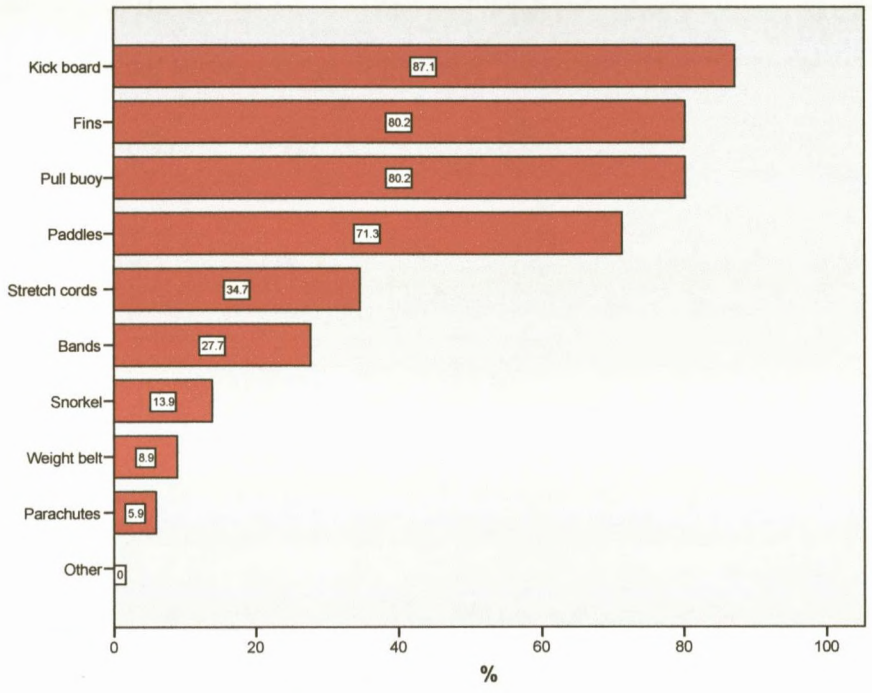

Figure 4.11: Types of equipment used

4.5.2.2.7 Participation in other Exercise or Sports (Q4- Q7 of CSIQ)

Seventy nine percent (79.2%) of participant's did another form of exercise other than swimming. This included gym (n=26, 34.6%), Pilates, weight training and running. Of these 35.4% had had an injury in the past due to the exercise, 66.7% of whom were prevented from swimming due to this injury.

Sixty nine percent (69.3%, n=70) of participants competed in another sport besides swimming. 53.6% reported injuries from competing in another sport, 83.8% of whom were prevented from swimming due to this injury.

4.5.2.2.8 Treatment history (Q34 of CSIQ)

Eighteen participants (17.8%) reported having regular maintenance treatment for preventative reasons. The type(s) of maintenance treatment that they received is shown in order of frequency in Figure 4.12. The most common was sports massage (9.9%), followed by chiropractic treatment (5.94%) and home treatment (5.94%).

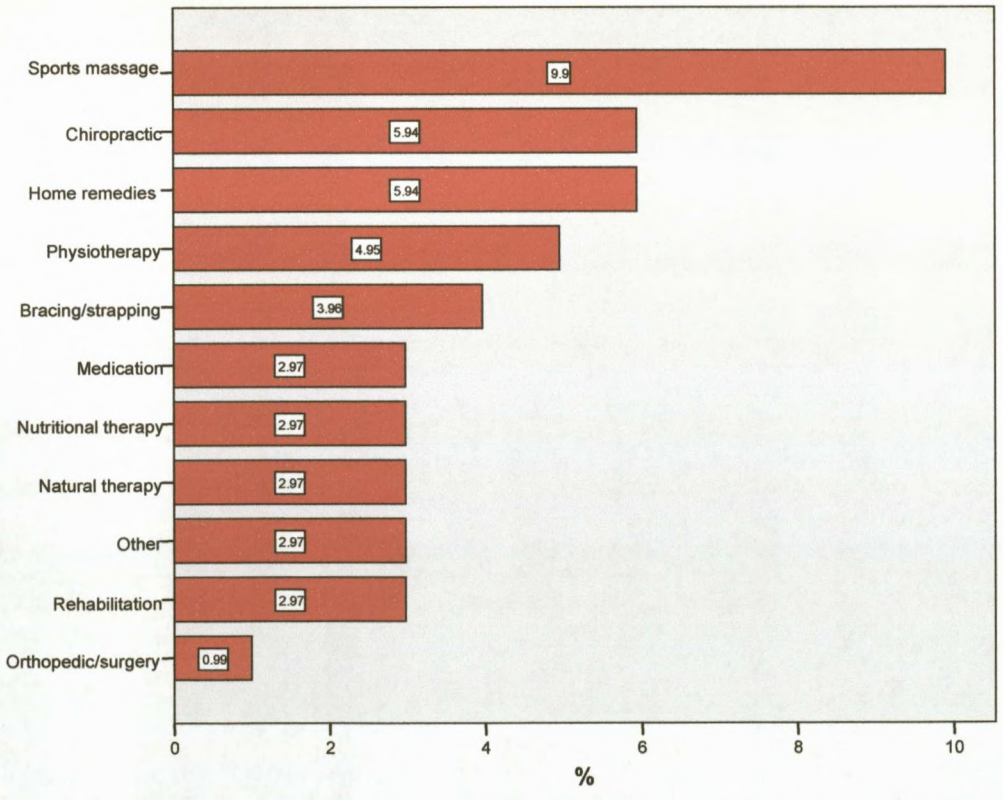

Figure 4.12: Percentage of participants who used various types of maintenance treatments

4.5.2.3. Prevalence of swimming injuries: Section 3 of the CSIQ

4.5.2.3.1 Lifetime prevalence of swimming injuries (Q37- Q40 of CSIQ)

The lifetime prevalence of injuries due to swimming was 53.5% (n=54). The most common site of injury was the shoulder (n=38, 70.4% of those who had ever injured themselves). The onset of the lifetime incidence of injuries were mainly over a period of time (56.9% and 56.3% of first and second injuries respectively). This is shown in Table 4.8.

Table 4.8: Onset of lifetime swimming injuries

	traumatic/accident		sudden onset		over a period of time	
	Count	Row %	Count	Row %	Count	Row %
Onset of injury 1	1	2.0%	21	41.2%	29	56.9%
Onset of injury 2	0	.0%	7	43.8%	9	56.3%

Of those who had ever injured themselves, 86.8% (46/53) had received treatment. The types of treatment they received are shown in Figure 4.13. Physiotherapy was the most common (64.2%), followed by massage (32.1%).

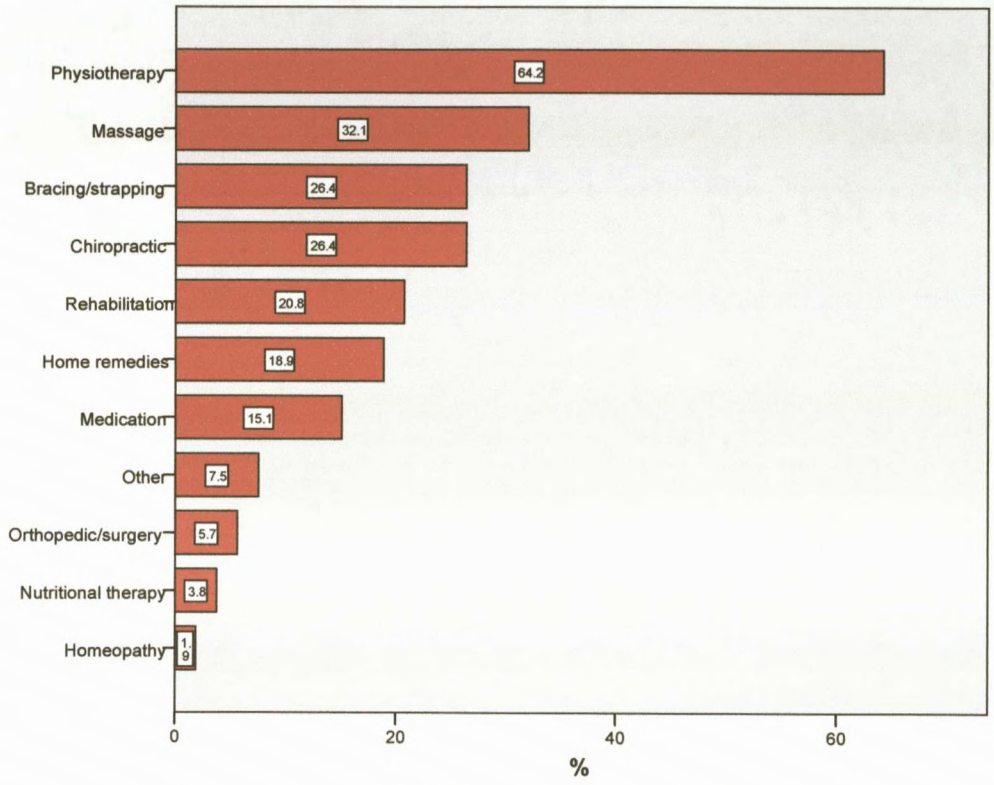

Figure 4.13: Percentage of participants who received various treatments in those who had ever had a swimming injury (n=54)

4.5.2.3.2 Frequency of swimming injuries (Q41a of the CSIQ)

Table 4.9 shows that of the injury sites listed, the majority of participants had never been injured. The shoulder was reported to be injured most frequently. Twenty four percent (24.1%) injured their shoulder seldom, while 33.38% injured the shoulder often and 20.4% reported very often injuring their shoulder. The

median response for each site was 0 (never) except in the case of the shoulder where the median response was 2 (often). It should be noted that with reference to this table the participants were able to indicate any injury that they have previous had.

Table 4.9: Frequency and percentage of lifetime injury to specific sites (n=54)

	Never		Seldom		Often		Very Often	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Foot/toes	41	75.9%	9	16.7%	3	5.6%	1	1.9%
Ankle	43	79.6%	6	11.1%	3	5.6%	2	3.7%
Achilles tendon	48	88.9%	3	5.6%	1	1.9%	2	3.7%
Leg	45	83.3%	8	14.8%	1	1.9%	0	.0%
Knee	34	63.0%	13	24.1%	6	11.1%	1	1.9%
Hamstring	47	87.0%	4	7.4%	3	5.6%	0	.0%
Quadriceps	47	87.0%	5	9.3%	2	3.7%	0	.0%
Hip/groin	39	72.2%	8	14.8%	5	9.3%	2	3.7%
Lower back	33	61.1%	11	20.4%	5	9.3%	5	9.3%
Upper back	45	83.3%	8	14.8%	0	.0%	1	1.9%
Neck	41	75.9%	10	18.5%	2	3.7%	1	1.9%
Head	51	94.4%	1	1.9%	2	3.7%	0	.0%
Shoulder	12	22.2%	13	24.1%	18	33.3%	11	20.4%
Biceps	44	81.5%	7	13.0%	3	5.6%	0	.0%
Triceps	46	85.2%	7	13.0%	1	1.9%	0	.0%
Elbow	45	83.3%	8	14.8%	1	1.9%	0	.0%
Forearm	51	94.4%	3	5.6%	0	.0%	0	.0%
Wrist	45	83.3%	5	9.3%	2	3.7%	2	3.7%
Hand	46	85.2%	5	9.3%	1	1.9%	2	3.7%
Other	52	96.3%	2	3.7%	0	.0%	0	.0%

4.5.2.3.3 The worst injury ever sustained due to swimming and its severity (Q41b and Q42 of the CSIQ)

Of those who had ever sustained an injury due to swimming, the area that sustained the worst injury was the shoulder (55.7%) of those reporting injuries. The shoulder was also reported most frequently as the site that sustained the second worst injury (58.3%).

The severity of their worst injury was mainly moderate (49.1%, n=26), while 17 (32.1%) were considered severe. This is shown in Figure 4.14.

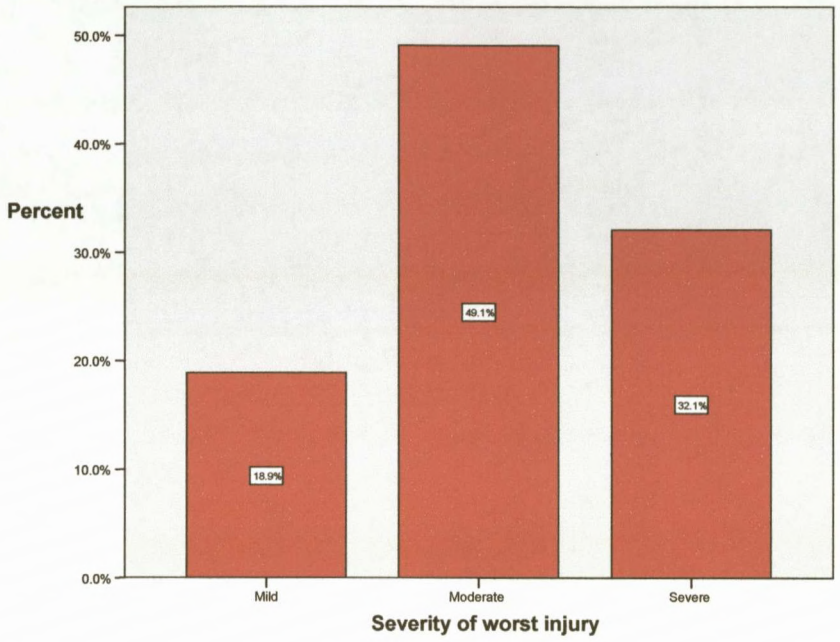

Figure 4.14: Severity of worst lifetime swimming injury (n=54)

4.5.2.3.4 Restriction due to injury (Q43 and Q44 of the CSIQ)

Shoulder injuries were most likely to prevent swimming (37%) or limit swimming (40.7%) rather than other types of injuries. This is shown in Table 4.10.

Table 4.10: Effect of injury at different sites in those who had a lifetime swimming injury (n=54)

	N/A		Prevented Swimming		Limited Swimming		no Effect	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Foot/toes	42	77.8%	3	5.6%	1	1.9%	8	14.8%
Ankle	42	77.8%	1	1.9%	5	9.3%	6	11.1%
Achilles tendon	47	87.0%	1	1.9%	2	3.7%	4	7.4%
Leg	45	83.3%	0	.0%	4	7.4%	5	9.3%
Knee	34	63.0%	4	7.4%	13	24.1%	3	5.6%
Hamstring	45	83.3%	1	1.9%	2	3.7%	6	11.1%
Quadriceps	46	85.2%	0	.0%	3	5.6%	5	9.3%
Hip/groin	40	74.1%	2	3.7%	6	11.1%	6	11.1%
Lower back	36	66.7%	6	11.1%	4	7.4%	8	14.8%
Upper back	44	81.5%	1	1.9%	2	3.7%	7	13.0%
Neck	45	83.3%	3	5.6%	1	1.9%	5	9.3%
Head	50	92.6%	0	.0%	0	.0%	4	7.4%
Shoulder	**7**	**13.0%**	**20**	**37.0%**	**22**	**40.7%**	**5**	**9.3%**
Biceps	47	87.0%	0	.0%	2	3.7%	5	9.3%
Triceps	48	88.9%	1	1.9%	0	.0%	5	9.3%
Elbow	44	81.5%	0	.0%	4	7.4%	6	11.1%
Forearm	50	92.6%	0	.0%	0	.0%	4	7.4%
Wrist	43	79.6%	1	1.9%	3	5.6%	7	13.0%
Hand	46	85.2%	0	.0%	1	1.9%	7	13.0%
Other	49	90.7%	0	.0%	0	.0%	5	9.3%

The period of being unable to swim was mainly less than one month (74%); only 10% were unable to swim for up to 3 months, while 8% were unable to swim for 3 to 6 months. This is shown in Figure 4.15.

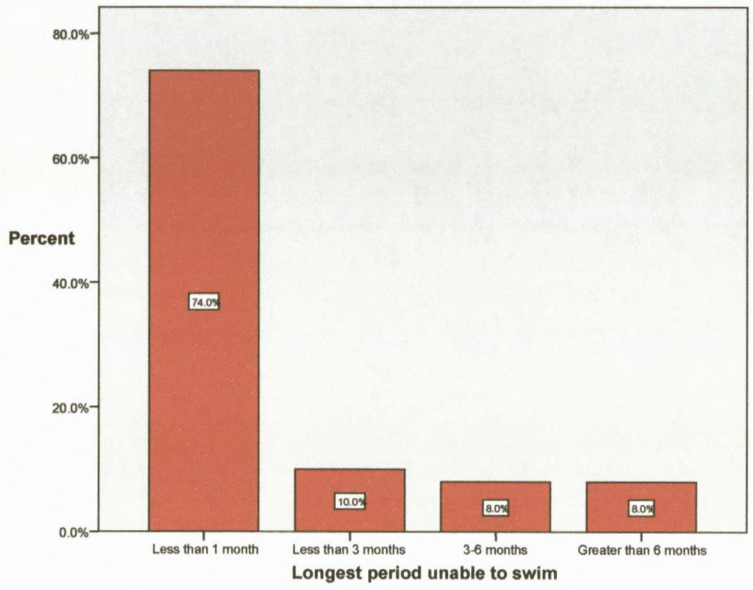

Figure 4.15: Longest period that injured participants were unable to swim for (n=54)

4.5.2.3.5 Perceived cause(s) of injury (Q45 and Q46 of the CSIQ)

Over training was blamed as the likely cause in the majority of cases (33.3%), followed by stretching in 31.5% and insufficient warm up in 25.9% of cases. This is shown in Figure 4.16.

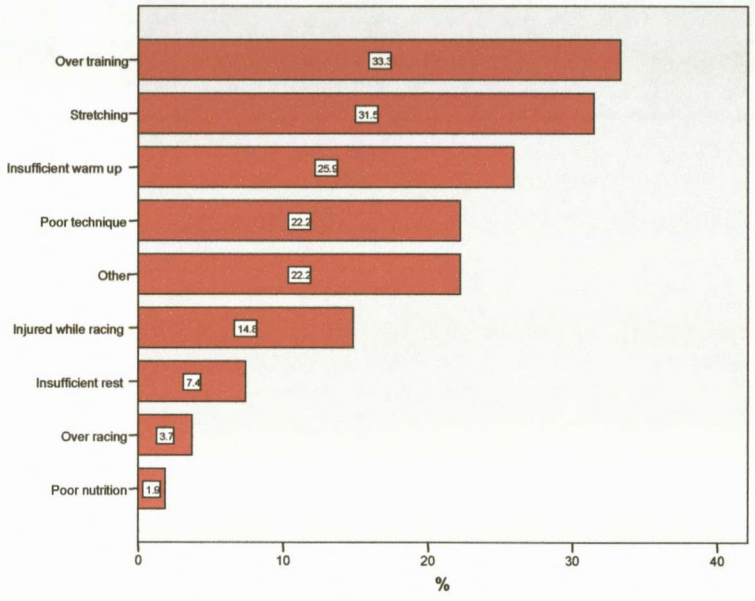

Figure 4.16: Most likely cause of injury in lifetime swimming injuries (n=54)

Freestyle and butterfly strokes were the activities during which most injuries were sustained (38.9% and 35.2% respectively), while using paddles was associated with 33.3% of the injuries. The other activities were infrequently reported. This is shown in Figure 4.17.

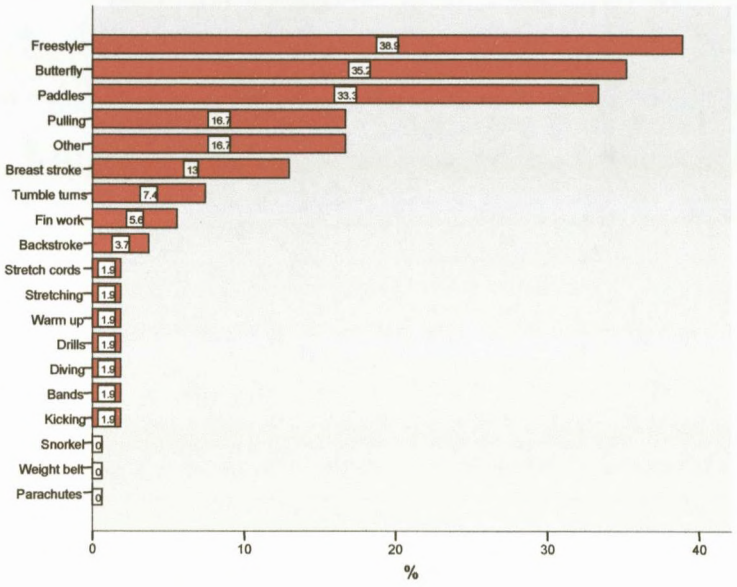

Figure 4.17: Activity during which injury was sustained (n=54)

4.5.2.4 Prevalence of Current Swimming Injuries: Section 4 of the CSIQ

4.5.2.4.1 Current Injuries (Q47 and Q48 of the CSIQ)

The current prevalence of swimming injuries was 17.8% (n=18). The vast majority injured their shoulder (61.1%), while the lower back was injured in 16.7% of cases and the knee and wrist in 11.1% each. This is shown in Table 4.11.

Table 4.11: Frequency of current injury at various sites (n=18)

	Count	Row %
Shoulder	11	61.11
Lower back	3	16.67
Knee	2	11.11
Wrist	2	11.11
Foot/toes	1	5.56
Ankle	1	5.56
Upper back	1	5.56
Neck	1	5.56
Collar Bone	1	5.56
Achilles tendon	0	0.00
Leg	0	0.00
Hamstring	0	0.00
Quadriceps	0	0.00
Hip/groin	0	0.00
Head	0	0.00
Biceps	0	0.00
Triceps	0	0.00
Elbow	0	0.00
Forearm	0	0.00
Hand	0	0.00

4.5.2.4.2 Treatment, severity and effects of current swimming injuries (Q49-Q54 of the CSIQ)

Of those who were currently injured, the majority had received treatment (n=14, 77.8%). Fifty percent received physiotherapy, while 33.3% used home remedies and 27.8% used bracing or strapping. 27.8% used chiropractic treatment. This is shown in Figure 4.18.

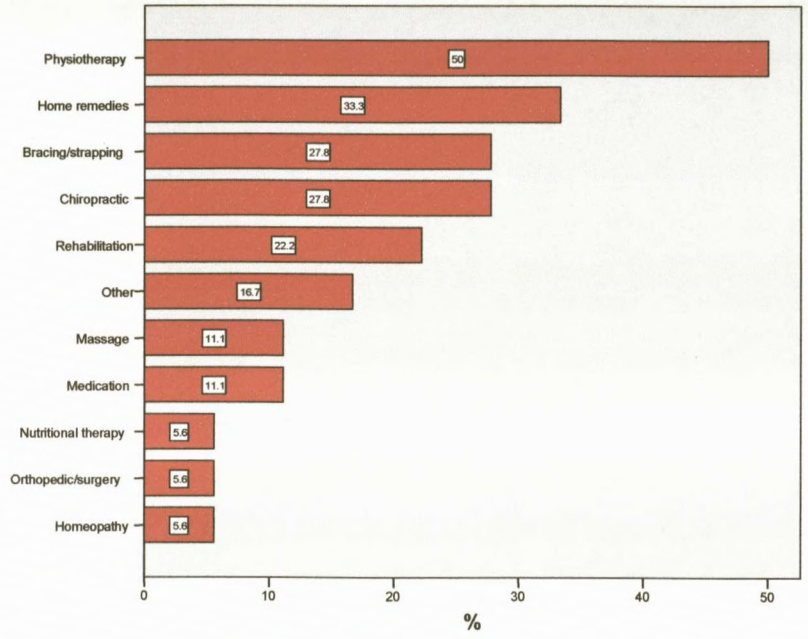

Figure 4.18: Percentage of current cases who had received various treatments for their injuries (n=14)

The mean level of pain in those with current injuries on a scale of 0 to 10 was 6.17 with a range from 3 to 10. The distribution of pain is shown in Figure 4.19.

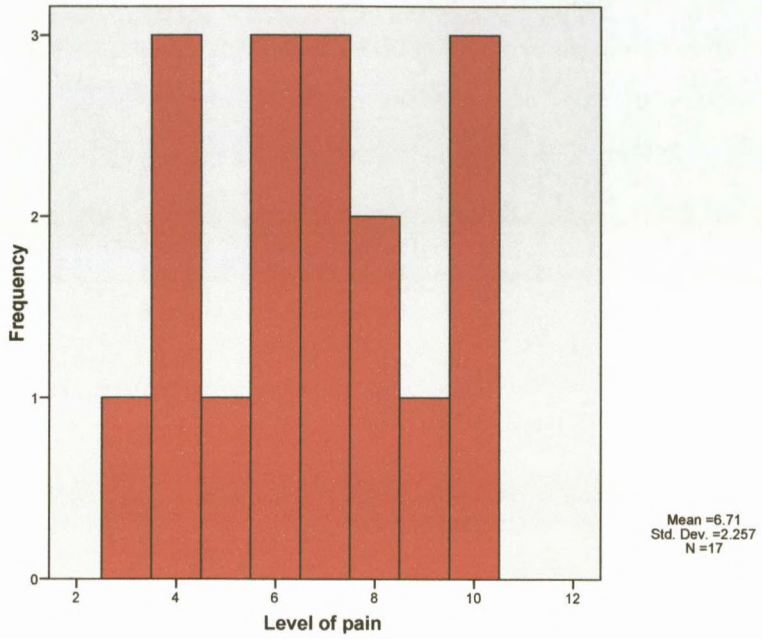

Figure 4.19: Histogram of pain level in those with current injuries (n=17)

Table 4.12 shows that the current injury was not likely to prevent swimming (11.8%) but mostly caused some pain (47%).

Table 4.12: "Does your present injury affect your swimming?" (n=17)

	Frequency	Valid Percent
Prevents swimming	2	11.8
Severe limitation and pain	2	11.8
Some limitation	3	17.6
Some pain	8	47
No effect	2	11.8
Total	17	100.0

Figure 4.20: shows that the majority had had the current injury for more than 6 months (47.1%), while 29.4% had been injured for less than one month.

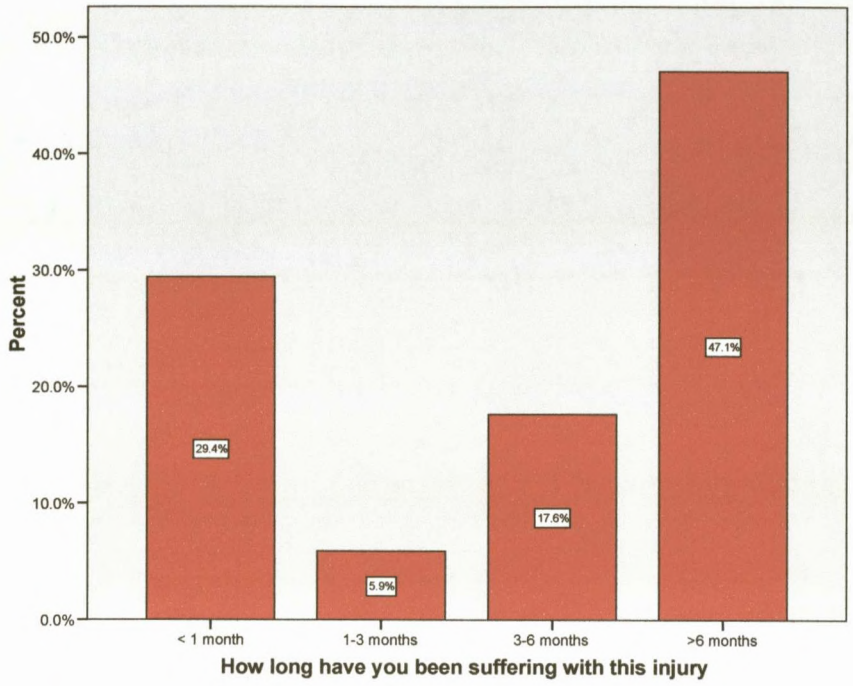

Figure 4.20: Length of time of current injuries (n=18)

The time period that currently injured participants were unable to swim for was mainly less than one month (82.4%). This is shown in Table 4.13.

Table 4.13: Time period that injury prevented currently injured participants from swimming (n=17)

	Frequency	Valid Percent
< 1 month	14	82.4
1-3 months	1	5.8
>6 months	2	11.8
Total	17	100.0

4.5.2.4.3 Perceived cause of the current swimming injuries (Q55-Q57 of the CSIQ)

Stretching was blamed for causing the current injury in 33.3% of cases, while 'other' causes were also sited in as many cases and over training in 27.8% of cases. This is shown in Figure 4.21. "Other" causes included; insufficient or the lack of stretching, poor training techniques, muscle weakness, an intense training regime, the use of hand paddles, tumble turns and dives.

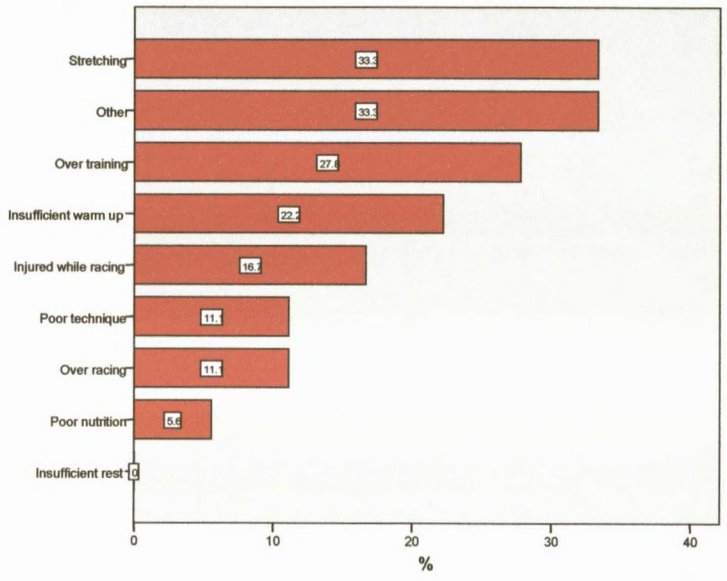

Figure 4.21: Cause of injury in currently injured participants (n=18)

The activity during which most of the current injuries were sustained was butterfly (38.9%), followed by using paddles (33.3%) and freestyle (27.8%). This is shown in Figure 4.22.

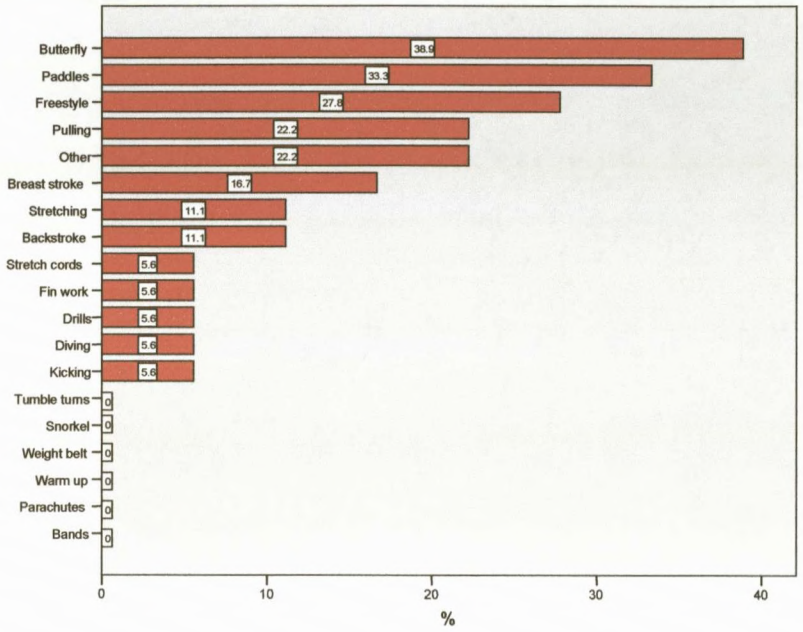

Figure 4.22: Activity during which the present injury was sustained (n=18)

Equal numbers of currently injured participants were injured during the beginning and mid-cycle of the swimming cycle (35.3%). This is shown in Table 4.14.

Table 4.14: Part of the swimming cycle during which currently injured participants were injured (n=17)

	Frequency	Valid Percent
Beginning	6	35.3
Mid-cycle	6	35.3
Hell week	4	23.5
Taper	1	5.9
Total	17	100.0

4.5.3 Objective 2: Was to identify the association between context factors (definition of the profile of musculoskeletal injuries pg xxii) and the report of the injury.

4.5.3.1 Multivariate analysis

In order to complete the multivariate analysis questions were identified through both a literature search as well as the focus group for inclusion into this process. For ease of reference these questions are referred to as factors that are either independently or dependently associated with the reported injury.

Table 4.15 shows the risk factors which were independently significantly associated with injury, along with their p values, odds ratios and 95% confidence intervals.

These risk factors identified in table 4.12 are adjusted for the effects of the other factors in the model, thus they represent the independent risks of these factors. Confounding variables that did not remain in the model.

The final statistical model contains 4 factors whereas 18 factors were inserted into the model at the start.

Fourteen excluded factors

- Q1 Age,
- Q4a Do you do any other form of exercise,
- Q5a Have you sustained an injury due to this exercise,
- Q7a Do you compete in any other sport,
- Q8 Have you sustained an injury due to this sport,
- Q15 How many years have you been swimming competitively,
- Q16 How many hours do you train swimming each week,

- Q17 What is the average duration of each swimming session,
- Q19 How many sessions do you swim each week,
- Q20 What is the average rest time between swimming sessions,
- Q21 How many hours of land training to you do per week,
- Q22 Hour many hours do you spend stretching per day,
- Q26 Type of swimmer- middle distance,
- Q36 Equipment used – with particular reference to bands.

Four remaining

1. The risk of swimming injury in those ever having injured themselves from another form of exercise was 3.8 times higher than those who did not do another form of exercise besides swimming.
2. Likewise the risk of swimming injury in those who had ever injured themselves due to another sport was 4 times higher than those who did not do another competitive sport.
3. The risk of injury increased significantly by 5.43 times with every one hour increased in the duration of the weekly swimming session, and
4. The risk increased by 1.57 times as the number of sessions swum per week increased by one.

Table 4.15: Final step (step 11a) in logistic regression analysis for risk factors for injury

		B	S.E.	Wald	df	p value	OR	95.0% C.I. for OR	
Step 11(a)	Injury from other exercise	1.336	.585	5.210	1	0.022	3.805	1.208	11.986
	Injury from other sport	1.395	.585	5.676	1	0.017	4.034	1.281	12.708
	Average duration of each swimming session	1.692	.845	4.008	1	0.045	5.430	1.036	28.452
	How many sessions per week	.455	.142	10.246	1	0.001	1.577	1.193	2.084
	Constant	-6.298	1.812	12.083	1	0.001	.002		

Variable(s) entered on step 1:

- Q1 Age,
- Q4a Do you do any other form of exercise,
- Q5a Have you sustained an injury due to this exercise,
- Q7a Do you compete in any other sport,
- Q8 Have you sustained an injury due to this sport,
- Q15 How many years have you been swimming competitively,
- Q16 How many hours do you train swimming each week,
- Q17 What is the average duration of each swimming session,
- Q19 How many sessions do you swim each week,
- Q20 What is the average rest time between swimming sessions,
- Q21 How many hours of land training to you do per week,
- Q22 Hour many hours do you spend stretching per day,
- Q26 Type of swimmer- middle distance,
- Q36 Equipment used – with particular reference to bands.

4.5.3.2 Bivariate analysis

The hypotheses indicated that there would be no relationship between the factors in the profile of musculoskeletal injuries and the reported injury in competitive swimmers in the greater Durban area.

4.5.3.2.1. Null hypothesis:

Mean age in those who have ever sustained a swimming injury is the same as those who have never sustained a swimming injury, i.e. age is not associated with having sustained a swimming injury.

Table 4.16 shows that there was a significant difference in mean age between the two injury groups (p=0.003), the null hypothesis is rejected and it is concluded that the mean age of the injured participants is older than those who have been never injured, so this study shows age is a risk factor for injury. However this needs to be interpreted with caution as it stands to reason that older individuals are more likely to report having had a previous injury.

Table 4.16: Comparison of mean age between injured and never injured

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Age	Yes	54	17.91	3.911	0.532	0.003
	No	47	15.32	4.640	0.677	

4.5.3.2.2. Null hypothesis:

There is no association between ***gender*** and injury

Table 4.17 shows that similar percentages of males and females had sustained an injury, and there was no significant association (p=0.366). Thus the null hypothesis is not rejected, and it is concluded that there is no association between gender and injury.

Table 4.17: Cross tabulation between gender and injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	yes
Gender	Male	Count	29	21	50
		% within Gender	58.0%	42.0%	100.0%
	Female	Count	25	26	51
		% within Gender	49.0%	51.0%	100.0%
Total		Count	54	47	101
		% within Gender	53.5%	46:5%	100.0%

Pearson's chi square = 0.818, p=0.366

4.5.3.2.3. Null hypothesis:

There is no association between ***ethnic group*** and injury.

Table 4.18 shows that there was no association between ethnic group and injury (p=0.706). However, there were low numbers of participants in the ethnic groups other than White, make some of the comparisons between ethnic groups invalid. Further larger and more representative studies would have to be performed to verify this finding. This null hypothesis was not rejected, and the findings were inconclusive.

Table 4.18: Cross tabulation between ethnic group and injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	yes
Ethnic group	Black	Count	1	0	1
		% within Ethnic group	100.0%	.0%	100.0%
	White	Count	48	42	90
		% within Ethnic group	53.3%	46.7%	100.0%
	Coloured	Count	3	4	7
		% within Ethnic group	42.9%	57.1%	100.0%
	Indian	Count	2	1	3
		% within Ethnic group	66.7%	33.3%	100.0%
Total		Count	54	47	101
		% within Ethnic group	53.5%	46.5%	100.0%

Pearson's chi square =1.398, p=0.706

4.5.3.2.4. Null hypothesis:

There is no association between taking part in ***other forms of exercise*** and sustaining a swimming injury.

There was a significant association between taking part in another form of exercise and swimming injuries (p=0.038). Table 4.19 shows that those who took part in another form of exercise were more likely to injure themselves in swimming. Thus the null hypothesis is rejected and it is concluded that taking part in another form of exercise is a risk factor for injury.

Table 4.19: Cross tabulation between other exercise and injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	yes
Other exercise	Yes	Count	47	33	80
		% within Other exercise	58.8%	41.3%	100.0%
	No	Count	7	14	21
		% within Other exercise	33.3%	66.7%	100.0%
Total		Count	54	47	101
		% within Other exercise	53.5%	46.5%	100.0%

Pearson's chi square=4.139, p=0.038

4.5.3.2.5. Null hypothesis:

Sustaining an ***injury due to taking part in another form of exercise*** is not associated with sustaining a swimming injury.

There was a significant association between sustaining an injury from taking part in another form of exercise form and sustaining a swimming injury (p=0.025). Those who had sustained another injury were more likely to have had a swimming injury (Table 4.20). Thus the null hypothesis is rejected and it is concluded that sustaining another injury from another form of exercise is a risk factor for further injury.

Table 4.20: Cross tabulation between other injury and swimming injury (n=79)

			Have you ever sustained an injury due to swimming		Total
			Yes	No	yes
Injury due to taking take in another form of exercise	Yes	Count	21	7	28
		% within Injury	75.0%	25.0%	100.0%
	No	Count	25	26	51
		% within Injury	49.0%	51.0%	100.0%
Total		Count	46	33	79
		% within Injury	58.2%	41.8%	100.0%

Pearson's chi square=5.016, p=0.025

4.5.3.2.6. Null hypothesis:

There is no association between taking part ***competitively in another sport*** and injury.

There was a borderline insignificant association between taking part in another sport and injury (p=0.056). Thus the null hypothesis is accepted; however there is a trend towards the risk of injury being higher in those who do not take part in another sport (table 4.21). Not taking part in another sport is not a significant risk factor for injury.

Table 4.21: Cross tabulation between other sport and injury

			Have you ever sustained an injury		Total
			Yes	No	
Other competitive sport	yes	Count	33	37	70
		% within other sport	47.1%	52.9%	100.0%
	No	Count	21	10	31
		% within other sport	67.7%	32.3%	100.0%
Total		Count	54	47	101
		% within other sport	53.5%	46.5%	100.0%

Pearson's chi square=3.664, p=0.056

4.5.3.2.7. Null hypothesis:

There is no association between ***sustaining an injury due to taking part in another competitive sport*** and swimming injury.

There was a significant association between being injured from another competitive sport and sustaining a swimming injury (p=0.002). Thus the null hypothesis is rejected and it is concluded that another sport injury is a risk factor for swimming injury (table 4.22).

Table 4.22: Cross tabulation between injury due to other sport and swimming injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	Yes
Injured due to another competitive sport	Yes	Count	24	13	37
		% within Injured due to other sport	64.9%	35.1%	100.0%
	No	Count	9	23	32
		% within Injured due to other sport	28.1%	71.9%	100.0%
Total		Count	33	36	69
		% within Injured due to other sport	47.8%	52.2%	100.0%

Pearson's chi square=9.282, p=0.002

4.5.3.2.8. Null hypothesis:

There is no association between eating a ***balanced diet*** and swimming injury.

Table 4.23 shows that there is no significant association between injured participants and those who did not eat a balanced diet and those who did not (p=0.808). So the null hypothesis is accepted and it is concluded that not eating a balanced diet is not a risk factor for swimming injury.

Table 4.23: Cross tabulation between balanced diet and swimming injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	Yes
Balanced diet	Yes	Count	45	40	85
		% within balanced diet	52.9%	47.1%	100.0%
	No	Count	9	7	16
		% within balanced diet	56.3%	43.8%	100.0%
Total		Count	54	47	101
		% within balanced diet	53.5%	46.5%	100.0%

Pearson's chi square =0.059, p=0.808

4.5.3.2.9. Null hypothesis:

There is no association between not ***taking supplements*** and swimming injury.

Table 4.24 shows that there was no significant association between taking supplements and injury (p=0.077), although the trend suggested that taking supplements was associated with swimming injury. The null hypothesis is not rejected, and it is concluded that taking supplements is not a risk factor for swimming injury.

Table 4.24: Cross tabulation between taking supplements and swimming injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	
Supplements	Yes	Count	43	30	73
		% within supplements	58.9%	41.1%	100.0%
	No	Count	11	17	28
		% within supplements	39.3%	60.7%	100.0%
Total		Count	54	47	101
		% within supplements	53.5%	46.5%	100.0%

Pearson's chi square=3.13, p=0.077

4.5.3.2.10 Null hypothesis:

There is no association between having ***hereditary diseases*** and swimming injury.

Table 4.25 shows there is no association between a hereditary disease and a swimming injury (p=0.810). The null hypothesis is not rejected and it is concluded that hereditary disease is not a risk factor for swimming injury.

Table 4.25: Cross tabulation between hereditary diseases and swimming injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	
Diseases	Yes	Count	10	8	18
		% within Diseases	55.6%	44.4%	100.0%
	No	Count	43	39	82
		% within Diseases	52.4%	47.6%	100.0%
Total		Count	53	47	100
		% within Diseases	53.0%	47.0%	100.0%

Pearson's chi square=0.058, p=0.810

4.5.3.2.11: Null hypothesis:

There is no association between ***Stretching*** and swimming injuries.

Stretching was not associated with swimming injury (p=0.123). However, the trend suggested that those who stretched before training were more at risk for swimming injury than those who never stretched. Even those who stretched before and after training or after training were at a higher risk for injury than those who never stretched. Even when the variable was recoded to yes/no for stretching, the p value was 0.08, indicating a non significant trend between stretching and risk of injury. Thus the null hypothesis is not rejected and it is concluded that stretching is not a risk factor for injury. This is shown in table 4.26.

Table 4.26: Cross tabulation between stretching and swimming injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	
When do you stretch	Before training	Count	34	18	52
		% within stretch	65.4%	34.6%	100.0%
	After training	Count	4	5	9
		% within stretch	44.4%	55.6%	100.0%
	Before and after training	Count	10	11	21
		% within stretch	47.6%	52.4%	100.0%
	Never	Count	6	11	17
		% within stretch	35.3%	64.7%	100.0%
Total		Count	54	45	99
		% within stretch	54.5%	45.5%	100.0%

Pearson's chi square=5.782, p=0.123

4.5.3.2.12. Null hypothesis:

There is no association between the ***age of starting swimming*** and swimming injuries.

Table 4.27 shows there was no association in mean age started swimming and participants who had injured themselves (p=0.961). Thus the null hypothesis is not rejected and it is concluded that age stated swimming is not a risk factor for injury. This is shown in table 4.27.

Table 4.27: Comparison between mean age started swimming and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Age started swimming	Yes	53	9.57	2.422	0.333	0.961
	No	46	9.54	2.084	0.307	

4.5.3.2.13. Null hypothesis:

There is no association between the ***duration of swimming competitively*** and swimming injuries.

Table 4.28 shows that there is a significant association between the duration of swimming competitively and swimming injuries (p=0.030). This study shows that those participants who were injured had been competing for a longer duration than those who had only recently begun competitive swimming. Thus the null hypothesis is rejected and it is concluded that duration of swimming competitively is a risk factor for injury.

Table 4.28: Comparison between mean duration of swimming competitively and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Years of swimming competitively	Yes	54	7.59	4.240	0.577	0.030
	No	46	5.71	4.275	0.630	

4.5.3.2.14. Null hypothesis:

There is no association between the ***number of hours swum per week*** and swimming injuries.

Table 4.29 shows there is a highly significant association between the greater number of hours swum per week and a swimming injury (p<0.001). Thus the null hypothesis is rejected and it is concluded that hours swum per week is a significant risk factor for injury.

Table 4.29: Comparison between mean duration of swimming per week and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Number of hours per week	Yes	54	12.91	4.410	0.600	<0.001
	No	47	8.99	4.527	0.660	

4.5.3.2.15. Null hypothesis:

There is no association between the ***duration of each session*** and swimming injury

Table 4.30 shows there is a significant association between longer session duration in those who sustained injury than in those who did not (p=0.004). Thus the null hypothesis is rejected and it is concluded that the duration of each session is associated with injury.

Table 4.30: Comparison between mean duration of session and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Duration of each session	Yes	54	1.880	.3320	0.0452	0.004
	No	47	1.670	.3763	0.0549	

4.5.3.2.16. Null hypothesis:

There is no association between the ***distance swum per week*** and the swimming injury.

Table 4.31 shows that there is an association between the distance swum per week and a swimming injury. Thu null hypothesis is rejected since the distance swum per week is significantly higher in the injured group than the non injured group (p=0.019). Thus it is concluded that distance swum per week is a risk factor for injury.

Table 4.31: Comparison between mean distance swum per week and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Number of km swim per week	Yes	53	36.311	16.2428	2.2311	0.019
	No	38	26.553	22.7886	3.6968	

4.5.3.2.17. Null hypothesis:

There is no association between the ***number of training sessions per week*** and the swimming injury.

Table 4.32 shows that there is an association between the number of training sessions per week and a swimming injury. Thus null hypothesis is rejected since the greater the number of sessions per week is significantly higher in the injured group than the non-injured group ($p<0.001$). So it is concluded that number of sessions swum per week is a risk factor for injury.

Table 4.32: Comparison between number of sessions per week and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Number of sessions per week	Yes	54	6.51	2.080	0.283	<0.001
	No	47	4.94	1.893	0.276	

4.5.3.2.18. Null hypothesis:

There is no association between ***rest time between sessions*** and swimming injury.

The null hypothesis is rejected since the rest time is significantly lower in the injured group than the non injured group ($p=0.001$). So it is concluded that reducing the rest time between sessions is a risk factor for injury. This is shown in table 4.33.

Table 4.33: Comparison between rest time between sessions and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Rest time between sessions	Yes	53	17.23	7.019	0.964	0.001
	No	44	22.56	8.928	1.346	

4.5.3.2.19. Null hypothesis:

There is no association between the ***number of hours of land training*** and swimming injury

The null hypothesis is rejected since the hours of land training is significantly higher in the injured group than the non injured group (p=0.013). Thus it is concluded that the number of hours spend doing land training is a risk factor for injury. This is shown in table 4.34.

Table 4.34: Comparison between hours of land training and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Hours of land training	Yes	54	3.36	2.283	0.311	0.013
	No	47	2.31	1.843	0.269	

4.5.3.2.20. Null hypothesis:

There is no association between the ***number of hours spent stretching*** and swimming injury

The null hypothesis is accepted as the hours of stretching is borderline significantly higher in the injured group than the non injured group (p=0.053). Thus it is concluded that the number of hours spent stretching may not be a risk factor for injury. This is shown in table 4.35.

Table 4.35: Comparison between hours spent stretching and injury

	Have you ever sustained an injury due to swimming	N	Mean	Std. Deviation	Std. Error Mean	p value
Hours spent stretching	Yes	53	0.470	0.3668	0.0504	0.053
	No	46	0.340	0.2774	0.0409	

4.5.3.2.21. Null hypothesis:

There is no association between the ***type of swimmer*** and swimming injury

Table 4.36 highlights that being a middle distance swimmer was significantly associated with injury (p=0.046). Thus the null hypothesis is rejected and it is concluded that middle distance swimming is a risk factor for injury.

Table 4.36: Type of swimmer by injury

		Have you ever sustained an injury due to swimming				P value
		Yes		No		
		Count	Row %	Count	Row %	
Sprinter	yes	44	55.7%	35	44.3%	0.295
	no	9	42.9%	12	57.1%	
Middle distance	yes	32	62.7%	19	37.3%	**0.046**
	no	21	42.9%	28	57.1%	
Long distance	yes	6	66.7%	3	33.3%	0.389
	no	47	51.6%	44	48.4%	
Open water	yes	4	50.0%	4	50.0%	0.859
	no	49	53.3%	43	46.7%	

4.5.3.2.22. Null hypothesis:

There is no association between the main stroke and swimming injuries.

There was no association between main stroke and injury (p=0.452). The percentage of participants that was injured in each main stroke (table 4.37) category was similar, except for individual medley, but the numbers were too low to show this conclusively. Thus the null hypothesis is not rejected and it is concluded that stroke is not associated with injury.

Table 4.37: Main stroke by injury

			Have you ever sustained an injury due to swimming		Total
			Yes	No	Yes
Main stroke	Butterfly	Count	12	10	22
		% within main stroke	54.5%	45.5%	100.0%
	Backstroke	Count	10	7	17
		% within main stroke	58.8%	41.2%	100.0%
	Breaststroke	Count	11	9	20
		% within main stroke	55.0%	45.0%	100.0%
	Freestyle	Count	21	18	39
		% within main stroke	53.8%	46.2%	100.0%
	Individual medley	Count	0	3	3
		% within main stroke	.0%	100.0%	100.0%
Total		Count	54	47	101
		% within main stroke	53.5%	46.5%	100.0%

Pearson's chi square = 4.675, p=0.452

4.5.3.2.23. Null hypothesis:

There is no association between the ***type of training equipment*** used and swimming injuries.

Table 4.38 shows that there is a significant association between the use of bands and swimming injuries (p=0.007) but not for any other equipment. Thus the null hypothesis is rejected; it is concluded that the use of bands was a risk factor for injury.

Table 4.38: Type of equipment by injury

		Have you ever sustained an injury due to swimming				p value
		Yes		No		
		Count	Row N %	Count	Row N %	
Kick board	yes	49	55.7%	39	44.3%	0.245
	no	5	38.5%	8	61.5%	
Pull buoy	yes	44	54.3%	37	45.7%	0.729
	no	10	50.0%	10	50.0%	
Weight belt	yes	3	33.3%	6	66.7%	0.205
	no	51	55.4%	41	44.6%	
Stretch cords	yes	20	57.1%	15	42.9%	0.589
	no	34	51.5%	32	48.5%	
Snorkel	yes	6	42.9%	8	57.1%	0.391
	no	48	55.2%	39	44.8%	
Other	yes	0	.0%	0	.0%	
	no	54	53.5%	47	46.5%	
Bands	yes	21	75.0%	7	25.0%	**0.007**
	no	33	45.2%	40	54.8%	
Fins	yes	43	53.1%	38	46.9%	0.878
	no	11	55.0%	9	45.0%	
Parachutes	yes	3	50.0%	3	50.0%	0.861
	no	51	53.7%	44	46.3%	
Paddles	yes	39	54.2%	33	45.8%	0.824
	no	15	51.7%	14	48.3%	

Chapter 5

Discussion of Results

5.1 Introduction

In this chapter we discuss the results of the statistical analysis in Chapter 4.

5.2 Outline of the Objectives of the Study

5.2.1 The First objective was to describe and summarize the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area, KwaZulu-Natal, South Africa with respect to questionnaire responses including an injury profile.

5.2.2 The Second objective was to identify the association between context factors (definition of the profile of musculoskeletal injuries pg xxii) and the report of the injury.

5.3 Results and comparison of results for this study with other studies

5.3.1 Response Rates

Stocker's *et al* (1995) study on Collegiate and Master's swimmer's where 25 questionnaires were sent to 100 Collegiate and 100 Master's swim teams respectively (to total 5000 questionnaires), surveying the incidence and possible factors associated with shoulder injuries. There were 532 Collegiate swimmers and 395 Master's swimmers that returned their questionnaires, thus yielding a response rate of slightly < 18%. Similarly the response rate in this study compares favourable with similar studies in other sporting codes (Adamson, 2006).

5.3.2 Objective 1

To describe and summarise the profile of musculoskeletal injuries in competitive swimmers in the Greater Durban Area with respect to questionnaire responses including an injury profile. In addition to this the data will be compared to available international literature.

5.3.2.1 Demographics

5.3.2.1.1 Age

The inclusion criterion for this study, in terms of age, was for participants to be between the ages of 10 and 30 years of age. This was based in the age range of registered swimmers from KZN aquatics. The participants who took part in this study fell within this range, with a mean age of 16.7 years. The age range in this study was consistent with other studies. Richardson's (1999) whose study focused on age group swimmers had an age distribution between 9 and 19 years of age. Stocker's *et al* (1995) study compared Collegiate and Master's swimmers thus having a mean age of 19.5 years and 41.5 years repetitively. Pieper and Schulte's (1996) study on elite German swimmers found a mean age of 18.0 years and the swimmers ages ranged between 11 to 27 years old.

5.3.2.1.2 Gender and Ethnic Distributions

The gender distribution in this study was similar with 50 males (49.5%) and 51 females (50.5%) participating. Based on the gender distribution of registered swimmers from KNZ aquatics 53% of registered swimmers in KZN were male and 47% were females. In light of these findings it might seem that the females were more willing to participant in this study, no further conclusions can be drawn to literature as no similar studies could be found.

The ethnic distribution was inequitable with only 1 black participant, 3 Indian participants and 7 Coloured participants. The remaining 90 participants (89.1%) were white. This makes it impossible to draw any strong conclusions regarding the association between ethnicity and swimming injuries because of the low numbers of non-white participants. Similarly comparison to international literature was limited as statistical comparisons are not possible.

5.3.2.1.3 Diet, Supplementation and Hereditary Disease history

A balanced diet was eaten by 83.8% of participants. Supplements were taken by 72.7% of participants. The types of supplements taken were mainly vitamins (62.6%) and protein shakes (35.4%), (Figure 4.1). For those who responded to "Other" the specified supplements included; Arthroguard, Carbohydrate drinks, Cytomax-training drink, Iron supplements, Staminade, l-glutamine, USN-zma, Phedro-cut and USN diet fuel (Figure 4.1; Table 4.3). Shamus and Shamus (2001), recommended that carbohydrate supplements be used during intense training, as they are the body's primary energy source. Costill *et al* (1992) found that protein supplementation did not enhance the adaptations associated with training. Further research is however required in order to conclusively make an association between the use of supplements and swimming injuries.

Hereditary disease were reported by 18 of the participants in this study (Table 4.4), with arthritis being the most common, 8 participants reported having a family history of arthritis although a specific type of arthritis was not named. Scoliosis was reported by 4 participants. "Other" hereditary disease that were identified in this study included Gout, Osgood Schlater's disease, Scheuermann's disease, Sever's disease, Hyperflexibility, Scoliosis and Spina bifida Occulta. Therefore the findings of this study indicated that up to 18% of participants had at least one hereditary disease which endorses Ferrell's (1999) recommendation that all swimmers should be evaluated clinically (including x-rays) to rule out possible precursors for injury. This evaluation however, will also allow for the assessment of non-disease precursors such

as flexibility; as Ferrell (1999), reports that swimming is a sport that favours flexibility of not only the extremities but also the spine. He is of the opinion that athletes with hyperflexibility are drawn to the sport (Ferrell, 1999) but that it also predisposes them to injuries.

5.3.2.2 Swimming History

5.3.2.2.1 Swimming History

As seen in Table 5.4 the mean age of participant's entry into competitive swimming was 9.6 years old (5 to 19 years old) with a standard deviation of 2.3 years.

Stocker *et al* (1995), identified the mean age of entry into competitive swimming for College level swimmers as being 9.1 years. However from her retrospective study she found that participants with shoulder pain had swam competitively from an earlier age with a mean age of entry into swimming being 8.8 years. Whereas Johnson *et al* (1987) found competitive swimmers to start their swimming career as young as 6 years old. McMaster and Troup (1993) had a mean age of entry into competitive swimmers for the National Age Group swimmers as being 8.1 years for girls and 7.8 years for boys. Therefore, the results of this study compare favourable with the literature (Stocker *et al.*, 1995; McMaster and Troup *et al.*, 1993; Johnson *et al.*, 1987).

In this study the number of years of swimming competitively ranged form 1 to 20 years of experience with a standard deviation of 4.3 years and mean value of 6.7 years (Table 4.5). Comparatively, Johnson *et al* (1987) estimated a swimmers career can last between 10 and 15 years; and Capaci *et al* (2002) estimated that a swimmers career may last only 8 to 12 years. This is similar to a study by Stocker *et al* (1995), who indicated that the total number of years of consistent competitive swimming was 10.1 years for the College athletes and 12.1 years for the Master's level swimmers.

In this study the number of hours of swimming training per week ranged between 2 to 25 hours per week. There was a standard deviation of 4.9 hours and a mean training time per week of 11.1 hours (Table 4.5). This compares favourably to a study by Capaci *et al* (2002), who found that swimmers spent over 10 hours per week training swimming. This however contrasts with Kammer *et al* (1999) who found that competitive swimmers train up to 22 hours per week.

The duration of the training sessions in this study ranged from 0.8 of an hour to 3 hours. The standard deviation of 0.4 hours and a mean training time of 1.8 hours of swimming training per session. (Table 4.5) Kammer *et al* (1999), found elite swimmers training generally utilised two-hour sessions.

The participants in this study swam between 2.5 km and 85 km per week. With a standard deviation of 19.7km and the mean kilometres swam per week was 32.2km (Table 4.5). This is in contrast to Johnson *et al* (1987), who indicated that swimmers train on average 5 to 7 days a week, with a distance of 7.3 to 18.2km per day. However, this study was in concurrence with McMaster and Troup (1993) who found that competitive swimmers swim on average 4.3 to 10km per day. The age of participants in this study may have played a role in the variability of these outcomes and it is suggested that future research be directed at the relation between age and the distance swum per week.

In this study participants swam between 2 and 11 session per week, with a standard deviation of 2.1 and a mean value of 5.8 sessions per week (Table 4.5). According to Shamus and Shamus (2001) competitive swimmers can train up to 10 to 12 swimming sessions per week which concurs with Kammer *et al.,* (1999) but is not similar to the outcomes of this study. The age of participants in this study may have played a role in the variability of these outcomes and it is suggested that future research be directed at the relation between age and the number of sessions swum per week.

The rest time participants had between sessions ranged form 6 to 48 hours with a standard deviation of 8.3 the mean rest time of participants between sessions was 19.6 hours (Table 4.5). Competitive swimmers are known for their early morning and late afternoon training sessions (Grote *et al.*, 2004; Shamus and Shamus, 2001).

The number of hours per week of land training (gym) was from zero (no land training) to 10 hours per week of land training. The standard deviation was 2.1 and the mean time spent land training was 2.9 hours per week (Table 4.5). Over and above the swimming training, swimmers also spent between 30 minutes and an hour doing land training (gym) three times a week (Shamus and Shamus, 2001). Land training includes weight training, running or cycling program (Shamus and Shamus, 2001). In a study by Kammer *et al.*, (1999) who found that 80% elite swimmer train an additional 30 to 50 minute of weight (land) training per week.

The number of hours spent stretching per day ranged from zero hours (no stretching) to 2 hours of stretching per day. The standard deviation of 0.3 hours, with a mean time spent stretching per day of 0.4 hours (Table 4.5). No literature could be found in order to compare the outcome.

The swimmers swam between 2 and 25 galas per season, with a mean number of galas swum being 8.9 galas per season (Table 4.5). This compares favourable with Grote *et al.*, (2004) who indicate that a swimmer usually competes in 10 minor competitions per year in which they swim a variety of events as well as 1 or 2 major competitions.

The number of races swum per gala varied from 2 to 12 races, with a mean number of races swum per gala being 5.8 races (Table 4.5). No literature could be found in order to compare the outcome.

5.3.2.2.2 Stretching History

Stretching history differed from the number of hours spent stretching as it requested information on when the swimmer stretched in comparison to there training sessions. In this study majority of swimmers (82.83%) spent some time stretching, either before training (52.53%) or after training (9.09%) and 21.21% of participants stretched before and after training. While 17.17% of participants didn't spend any time stretching at all (Figure 4.2). This is in contrast to a study by McMaster and Troup (1993), who indicate that 90.5% of National age group swimmers in the USA and 93% of both the senior elite development and elite swimmers had a stretching routine. Furthermore it would seem to suggest that the participants in this study would be more prone to injury, as Capaci *et al* (2002) suggests that stretching prior to training as well as a proper warm up routines are essential in injury prevention.

5.3.2.2.3 Stroke, Distance and Event History

With reference to Table 4.6 and figures 4.3 to 4.9, Freestyle was the most common main stroke (n=39, 38.6%) followed by 21.8% of the participants having Butterfly as the main stroke. In addition it was noted that the majority of swimmers classified themselves as being sprinters (78.2%), while 50.5% classified themselves as being middle distances swimmers. In addition the most popular main event was the 100m Freestyle, followed by the 50m Freestyle and then 50m and 100m Butterfly. No literature could be found in order to compare the outcome.

5.3.2.2.4 Breathing Style

Bilateral breathing was the most common style of breathing (40.6%), with a similar number of participants breathing either to the right (31.7%) or left hand side (27.7%), (Table 4.7). This contrasts with the findings in College swimmers of which 55% breathed bilaterally, 31% breathed to their right hand side and the remaining 14% breathed to their left hand side; however, it

compares favourable with Master's swimmers of which 42% breathed to their right side, 32% breathed bilaterally and 26% breathed to their left hand side (Stocker *et al.*, 1995). Based on these results it would seem to suggest a common denominator between the participants in this study and the Master's swimmers in a study by Stocker *et al* (1995); or alternatively that there is a distinguishing factor in the College swimming group analysed by Stocker *et al* (1995). A possible difference could be related to higher demands placed on the College swimmer as compared to the older or younger swimmer. This assertion however requires further research.

5.3.2.2.5 Level of Competition

Participants in this study mainly swam at a National level (38.6%), with a similar percentage of swimmers competing at a Provincial (24.75%) or International level (23.76%). Lowest level of competition in participants was schools level were only 12.87% of participants competed (Figure 4.10). No literature could be found in order to compare the outcome.

5.3.2.2.6 Stroke Correction and the Equipment Used

In congruence with Kammer *et al* (1999) the results of this study indicated that regular stroke correction was received by majority of the participants (n=59, 58.4%). Thus most competitive swimmers receive a large amount of stroke correction from a young age, as proper stroke techniques increase a swimmers ability to train at high intensities and remain injury free.

In order to assist with training a variety of swimming equipment was used by participants in this study, with the kick board being the most commonly used with 87.1% of participants using it, followed by a pull buoy and fins (80.2% each) and 71.3% of participants used hand paddles (Figure 4.11). Limited comparisons to literature are possible based on the fact that reported equipment is always in the context of injuries associated with the use of the equipment (Jones, 1999; Pieper and Schulte, 1996; McMaster and Troup,

1993; Johnson et al., 1987). However, the limitations of this comparison do not necessarily negate the possibility that the kick board, pull buoy, fins and or hand paddles could be a cause of injury in this study (see objective two for further discussion).

5.3.2.2.7 Participation in Other Exercise or Sports

Another form of exercise other than swimming was participated in by 79.2% of participants in this study. This mainly involved gym (n=35, 34.6%), Pilates, weight training and running. Thirty five percent (35.4%) of the participants had had an injury in the past due to the exercise in which they participated, 66.7% of which were prevented from swimming due to this injury. No literature could be found in order to make a direct comparison to the outcomes of this study.

Sixty nine percent (69.3%, n=70) of participants competed in another sport besides swimming. Injuries from competing in another sport were reported in 53.6% of participants, 83.8% of whom were prevented from swimming due to this injury. No literature could be found in order to make a direct comparison to the outcomes of this study.

5.3.2.2.8 Treatment History

Regular preventative treatment was reported by 17.8% of the participants. Sports massage (9.9%), followed by Chiropractic treatment (5.94%) was seen as being the most common forms of maintenance treatment (Figure 4.12). Grote *et al* (2004) found that only 4.5% of participants in their study received frequent massages no comment was made on any other form of treatment. In a study by Stocker *et al* (1999), ice was the mostly frequently used treatment modality by the College swimmers, while the Master's swimmers treatment was rest and Nonsteroidal Anti-Inflammatory Drugs (NSAID's). Similarly treatment modalities used for lumbar pain in swimmers included rest, ice, massage and postural exercises (Ferrell, 1999).

5.3.2.3 Prevalence of Swimming Injuries

5.3.2.3.1 Lifetime Prevalence of Swimming Injuries

Fifty four percent (53.5%) of competitive swimmers had a lifetime prevalence of swimming injuries. Of those previously injured the most commonly injured area was the shoulder (n=38, 70.4%). The onset of lifetime injuries were insidious and not as a result of direct trauma. (Table 4.8)

In addition of the participants who had ever injured themselves, 86.8% (n=53) received treatment. The most common treatment received was Physiotherapy (64.2%), followed by massage (32.1%).

Stocker *et al* (1995) found 55% of the injured College swimmer and 39% of the Master's swimmers received treatment for their shoulder injuries. This comparison is limited because the results reported by Stocker *et al* (1999) indicate only those injuries/ those injured that required treatment and therefore excludes those injuries for which no treatment was sort.

5.3.2.3.2 Frequency of Swimming Injuries

With reference to Table 4.9 the participants that had ever sustained an injury due to swimming, the shoulder was reported as being the most frequently injured. Twenty four percent (24.1%) of participants seldom (once or twice in their swimming career) injured their shoulder; 33.3% of participants injured their shoulder often (3- 5 times) and 20.4% injured their shoulder very often (more than five times).

Similarly the knee was reported to have been seldom injured (24.1%), with 11.1% reporting that injured their knee often. In addition nine percent (9.3%) of participants reported having injured their lower back often or very often, while 20.4% seldom injured their lower back.

These results compare in part with Capaci *et al* (2002) who found that 23 of the 38 competitive swimmers who participated in their study had a musculoskeletal injury. Shoulder injuries were identified as the most common site of injury (38.2%), followed by lower back pain (18.4%) and then by knee pain (7.9%). However, the results contrast with McMaster and Troup's (1993) study on shoulder pain in competitive swimmers who found 38% to 75% of their participants had a history of shoulder pain.

5.3.2.3.3 The Worst Injury Ever Sustained due to Swimming and its Severity

Of those participants who had ever sustained an injury due to swimming, the shoulder (55.7%) was reported to be the area that sustained the worst injuries. The results obtained by McMaster and Troup (1993) compare favourably with this study. The shoulder was also reported most frequently as the area that sustained the second worst injury rate (58.3%) in those swimmers that had rated another injury as their worst injury ever.

Participants reported the severity of their worst injury as being moderate (49.1%, n=26), while 32.1% reported their injury as being severe (Figure 4.14). No literature could be found in order to make a direct comparison to the outcomes of this study.

5.3.2.3.4 Restriction due to Injury

With reference to Table 4.10 and Figure 4.15 shoulder injuries were the most likely injury to **prevent** swimming (37%), followed by lower back injuries (11.1%) and knee injuries (7.4%).

Shoulder injuries were also the most common site to **limit** swimming (40.7%).From responses noted on the CSIQ, limitations due to shoulder injuries only allowed the swimmer to kick; prevented the swimmer from pulling or from swimming Butterfly as well as limited the use of hand paddles.

Knee injuries limited swimming in 24.1% of participants with knee injuries, allowing the swimmer to pull only and prevented the swimmer from doing tumble turns and Breaststroke, especially the Breaststroke kick. Furthermore 11.1% of participants with hip or groin injuries were limited to only doing pull and avoiding Breaststroke especially the Breaststroke kick.

Although resting the injured area of the body is ideal in order to protect it from being injured further, as is evident from the response in the CSIQ; swimmers will continue activities in order to maintain their high level of fitness without aggravating the injuries. These mechanisms will decrease the stress on the injured area while still exercising uninjured areas (Capaci *et al.*, 2002).

This concurs with Capaci *et al* (2002) who indicate that kicking and dry land training may be done if the swimmer has an injury to the upper extremity. However, in cases of severe injury the swimmer may require total rest of the injured area. "Relative rest" may include land training exercises, kicking, jogging or cycling maybe done to maintain the swimmers fitness (Johnson *et al.*, 1987).

With respect to enforced rest the majority of participants (74%) were unable to swim for up to 1 month, with only 10% of participants being unable to swim for up to 3 months, while 8% of participants had injuries that prevent them from swimming for greater than 6 months. This does not compare with Capaci *et al* (2002) who reported that more than 50% of the participants felt their pain had a mild influence on their degree of training. The other participants did not stop their degree of training, with the exception of one participant who was unable to swim for 1 month (Capaci *et al.*, 2002).

5.3.2.3.5 Perceived Cause(s) of Injury

Participants blamed over training as the main cause for their injuries (33.3%) followed by stretching (31.5%) and insufficient warm up (25.9%). Poor technique (22.2%) was also identified as a perceived cause of injury. "Other" causes accounted for 22.2% of injuries; theses included the lack of stretching and an intense training regime as well as hereditary (see section 5.3.2.1.3) and medical conditions. (Figures 4.16)

Similarly an increase in training intensity and or an increase in the distance swum (over training) were perceived by >50% of injured to swimmer to be the cause of their shoulder injuries (Stocker *et al.*, 1995). In addition Grote *et al* (2004) found a correlation between the increase in training distance (over training) in Breaststroke and hip adductor injuries.

With respect to stretching, a study by McMaster and Troup (1993) revealed that stretching aggravated existing shoulder injuries in swimmers. They found that this was largely due to the buddy-assisted stretching techniques in which the swimmer horizontally abducts both their arms to their extreme range of motion (ROM) with the assistance of their partner. This concurs with the findings in this study (Figure 4.16), as do the results achieved by Stocker *et al* (1995) who indicated that the effectiveness of a proper warm-up prior to swimming is of the utmost importance and should not be ignored as it maybe a precursor to injury.

In this study (Figure 4.17) Freestyle and Butterfly were the activities during which the most injuries were sustained (38.9% and 35.2% respectively).There is no comparable literature with respect to correlation between strokes and injuries. Although anecdotal evidence (KZN Aquatics, 2007) suggest that there is. It is there suggested that future research be done in this area.

Hand paddles (Figure 4.17) were also identified as being associated with 33.3% of injuries and "other" factors accounted for 16.7% of injuries; theses

included gym or land training and being injured while racing. (Figure 4.17) These results confirm with McMaster (1999) who identified resistance weight training as a causative factor in shoulder injuries in competitive swimmers. In addition it concurred with Ferrell (1999) who identified back pain as frequently being a result of a non-swimming event, such as dry land training, or other recreational activities that a swimmer main be involved in which is carried over thus having an effect on a swimmers performance (Ferrell, 1999).

Furthermore, hand paddles were used by over 70% of both the College and Master's swimmers that reported sustaining a shoulder injury. However, only 21% of College and 16% of Master's swimmers reported that the shoulder pain started immediately after using the hand paddles (Stocker *et al.*, 1995). This comparison seems to suggest that the use of hand paddles in this study, where the mean age was 16.7 years, may that hand paddles are incorrectly utilised by the younger swimmers or alternatively the hand paddles are not ergonomically sound for this age group. It is therefore suggested that further research be directed in this area.

5.3.2.4 Prevalence of Current Swimming Injuries

5.3.2.4.1 Current Injuries

Table 4.11 shows the prevalence of current swimming injuries was 17.8% (n=18) of this number the majority of swimmers injured their shoulder (61.1%). The lower back was the second most commonly injured site with 16.67% of the injuries. Participants reported injuries to the knee and the wrist in 11.1% of the case each. This does not compares favourably with McMaster and Troup's (1993) who reported in their study on shoulder pain in competitive swimmers that only 9% to 35% of participants were currently injured.

Similarly the results of this study, (Table 4.11) do not compare with Capaci *et al* (2002) who indicate the prevalence of musculoskeletal injuries as being 60.52%. In addition the results contrast with respect to shoulder injuries,

which Capaci *et al* (2002) identified as the most commonly injured at 38.2%, followed by lower back pain which was ranked as the second most commonly injured site (18.4%). However in a study by Rodeo (1999), it found that knee pain, ranked second to shoulder pain as being the most common musculoskeletal injury in competitive swimmers, which was in contrast to Capaci's *et al* (2002) study. These findings in totality seem to share a common trend with respect to affected regions even through the percentages obtained vary significantly.

5.3.2.4.2 Treatment, Severity and Effects of Current Swimming Injuries (Figure 4.18 and Table 4.12 and 4.13)

Of the participants that were currently injured, the majority received treatment (77.8%, n=14), with Physiotherapy being the most common form of treatment (50%); followed by home remedies (33.3%) which included icing the affected area. Twenty seven percent opted for Chiropractic treatment, bracing and/ or strapping, with "other" treatments accounting for 16.7% of interventions. These interventions included; dry needling, acupuncture and Biokinetics. These results are disproportionate to the results achieved by Grote *et al* (2004) where 15% of the swimmers received some form of treatment from a Physiotherapist, while 9% consulted their physician and 5% received Chiropractic treatment. Differences to the results obtained as a result of the response options allowed within questionnaires in each study.

The level of pain experienced by participants with current injuries was on a scale of 0 to 10, with zero representing no pain and 10 representing severe pain. The mean level of pain was 6.71 with a range of 3 to 10 and a Standard deviation of 2.257(Figure 4.20). No literature could be found in order to make a direct comparison to the outcomes of this study.

The participants in this study complained that their current injuries caused the most pain (47.1%). This resulted in 17.6% limiting their swimming training. These swimmers stated they were unable to swim Butterfly and Breaststroke

especially because of the Breaststroke kick. They reported that they were not allowed to use hand paddles or do tumble turns. Some participants were only able to kick or pull. Twelve percent (11.8%) of participants were prevented from swimming altogether. This follows the trends found by Capaci *et al* (2002) who reported that more than 50% of the participants felt their pain had a mild influence on their degree of training. The other participants did not stop their degree of training, with the exception of one participant who was unable to swim for 1 month (Capaci *et al.*, 2002). The time period that the currently injured participant was unable to swim for was predominately less than one month (82.4%). Twelve percent (11.8%) of the currently injured participants were prevented from swimming for greater than 6 months (Table 4.12).

Furthermore, the recommendation that the swimmers avoid the use of hand paddles as they have been found to aggravate shoulder injuries in swimmers (Johnson *et al.*, 1987); concurs with the findings in Table 4.11 where shoulder injuries are indicated as the most common current injury.

Majority of the currently injured participants had been suffering with their injuries for more than 6 months (47.1%), while 29.4% of participants had been currently injured for less than 1 month. These findings suggest repetitive strain injuries which are similar to those reported by Shamus and Shamus, (2001) and Rodeo, (1999).

5.3.2.4.3 Perceived Cause of the Current Swimming Injuries

Stretching was largely blamed for the current injuries, in 33.3% of the case (Figure 4.21). "Other" causes were to blame in 33.3% of cases, which included; insufficient or the lack of stretching; poor training techniques; muscle weakness; an intense training regime; the use of hand paddles; tumble turns and dives. Medical or hereditary conditions were also seen as an "other" cause for the current injuries. Over training was identified as a causative factor for their current injury in 27.8% of cases.

In concurrence with the above Kammer *et al* (1999) found that weight training; excessive stretching exercises, improper stretching and partner stretching were all seen to aggravate injuries. In concurrence, Stocker *et al* (1995) and McMaster and Troup (1993) found stretching to aggravate shoulder injuries, especially when using the buddy stretching techniques. In addition poor flexibility predisposed swimmers to injuries (Kammer *et al.*, 1999).

Butterfly (38.9%) was identified as an activity during which caused most of the current injuries occurred; followed by the use of paddles (33.3%) and Freestyle (27.8%), (Figure 4.22). Butterfly was found to be the stroke that aggravated shoulder pain as it is the most difficult stroke to execute (McMaster and Troup, 1993).

Furthermore, they also identified the use of hand paddles, kick boards, stretching and weight training as factors aggravating shoulder injuries in swimmers (McMaster and Troup, 1993). Richardson *et al* (1980), sited in Johnson *et al* (1987), also found that hand paddles increased shoulder pain in 81% of participants in their study.

An equal number of participants were injured during the beginning and middle of the swimming cycle (35.3%), (Table 4.14). Shoulder pain was found to be worse during the beginning or middle of the season in 83% of participants (Richardson *et al.*, 1980, sited in Johnson *et al.*, 1987). Breaststroke swimmers who experienced hip pain, report that their injuries were mostly likely to occur at the beginning to the middle of their season (Grote *et al.*, 2004).

5.3.3 Objective 2

5.3.3.1 Multivariate Analysis

Of the 14 risk factors that were inserted into this statistical model (multivariate regression analysis) there were only 4 factors that were shown to be independently significantly associated with swimming injuries.

The 10 excluded risk factors are listed below as;

- Age,
- Doing any other form of exercise,
- Competing in any other sport,
- The number of years that they have been swimming competitively,
- The number of hours they train swimming per week,
- The average rest time between swimming sessions,
- The number of hours of land training they do per week,
- The number of hours they spend stretching per day,
- The type of swimmer they are (the middle distance swimmer),
- The equipment they use (the use of bands during training).

The 4 factors that were included in this model were;

- Participants having sustained an injury from another form of exercise,
- Participants having sustained an injury from another sport in which they compete,
- The average duration of each swimming session
- The number of swimming session per week

Capaci *et al* (2002), found no significant association in age between the injured and non injured swimmers. This indicates that age may not be an independent risk factor in the development of a musculoskeletal injury in swimmers, which concurs with the findings in this study. Richardson *et al* (1980) sited in Johnson *et al* (1987) found that the incidence of shoulder

injuries increased with the increased calibre of swimmer. Shoulder injuries were reported by 27% of non-elite swimmers versus the 52% to 57% of elite swimmer's reporting shoulder injuries. McMaster and Troup (1993) found that the number of swimmers suffering with shoulder injuries increased with the skill level of the swimmer and presumably the number of years that they had participated in the sport. The number of years of training and the duration of the swimming training per week were identified as significant risk factors for the development of swimming injuries (Capaci *et al.*, 2002). This may indicate that a longer period of training will increase the chance of sustaining a musculoskeletal injury. The longer you training may also be included as a possible risk factor for musculoskeletal pain in swimmers (Capaci *et al.*, 2002). Musculoskeletal pain was current in swimmers with a longer history of training and those who spent more time training. A Significant statistical correlation ($p = < 0.05$) between pain, number of years of training and weekly training time (Capaci *et al.*, 2002).

This concurs with the findings in this study that the average duration of each swimming session, the number of sessions and the participant in an other form of exercise may all be related to developing the increased calibre of the swimmer in addition to each being independent risk factors for injury.

The type of swimmer; the distance they swim and their speciality stroke, with the possible exception of Butterfly, are not identified as having an influence on the incidence of shoulder pain (Kammer *et al.*, 1999). The reported incidence of shoulder injuries was equal between male and female swimmers according to Johnson *et al* (1987) study on musculoskeletal injuries in competitive swimmers.

Research has shown that long distance Freestyle swimmers have been described as having a high pain tolerance and therefore don't tend to be complainers. Whereas Freestyle sprinters have been found to complain more readily about there pain (James, 1999).

5.3.3.2 Summary of Findings

5.3.3.2.1 Significant Statistical Findings

The significant statistical findings related to this study are listed in Table 5.1 below.

Table 5.1: Significant Statistical Findings

Rank	Significant Risk Factors Associated with Swimming Injuries	p value
1	Number of training sessions per week	p= <0.001
1	Number hours swum per week	p= < 0.001
2	Rest between each session	P= 0.001
3	Injury from another Competitive Sport	p= 0.002
4	Age	p= 0.003
5	Duration of each session	p= 0.004
6	Bands (Training Equipment used)	p= 0.007
7	Number of hours of Land Training	p= 0.013
8	Distance (km) swum per week	p= 0.019
9	Injury from another form of exercise	p= 0.025
10	Number of years of Competitive Swimming	p= 0.030
11	Participation in other forms of Exercise	p= 0.038
12	Middle Distance Swimmer (Type of Swimmer)	p= 0.046

5.3.3.2.2 Insignificant Statistical Findings

The insignificant statistical findings related to this study are listed in Table 5.2 below.

Table 5.2: Insignificant Statistical Findings

Rank	Insignificant Risk Factors Associated to Swimming Injuries	p value
1	Age started Swimming	p= 0.961
2	Fins (Training Equipment used)	p= 0.878
3	Parachutes (Training Equipment used)	p= 0.861
4	Open Water Swimmer (Type of Swimmer)	p= 0.859
5	Paddles (Training Equipment used)	p= 0.824
6	Hereditary diseases	p= 0.810
7	Balanced Diet	p= 0.808
8	Pull Buoy (Training Equipment used)	p=0.729
9	Ethnic Group	p= 0.706
10	Stretch Cords (Training Equipment used)	p= 0.589
11	Main Stroke	p= 0.452
12	Snorkel (Training Equipment used)	p= 0.391
13	Long Distance Swimmer (Type of Swimmer)	p= 0.389
14	Gender	p= 0.366
15	Sprinter (Type of Swimmer)	p= 0.295
16	Kick Board (Training Equipment used)	p= 0.245
17	Weight Belt (Training Equipment used)	p= 0.205
18	Stretching	p= 0.123

5.3.3.2.3 Borderline Statistical Findings

The borderline statistical findings related to this study are listed in Table 5.3 below.

Table 5.3: Borderline Statistical Findings

Rank	Borderline Risk Factors Associated to Swimming Injuries	p value
1	Number of hours spent Stretching	p= 0.053
2	Competing in other Sports	p= 0.056
3	Supplements	p= 0.077

5.4 Summary of the Hypotheses

5.4.1 *The First hypothesis was that the profile of musculoskeletal injuries in Competitive swimmers in the Greater Durban Area will differ from those of other countries.*

Accepted

5.4.2 *The Second hypothesis indicated that there would be no relationship between the factors in the profile of musculoskeletal injuries in competitive swimmers in the Greater Durban Area.*

Table 5.4 Table indicating the accepted and rejected hypothesis

Rejected Hypothesis	Accepted Hypothesis
◦ Age ◦ Other forms of exercise ◦ Injury due to taking part in another form of exercise ◦ Sustaining an injury due to taking part in another competitive sport ◦ Duration of competitive swimming ◦ Number of hours swum per week ◦ Duration of each session ◦ Distance swum per week ◦ Number of training sessions ◦ Rest time between sessions ◦ Number of hours of land training ◦ Type of swimmer – middle distance swimmer ◦ Training equipment- Bands	◦ Gender ◦ Ethnic group ◦ Balanced diet ◦ Hereditary diseases in the family ◦ Stretching ◦ Age started swimming ◦ Main stroke ◦ Supplements ◦ Competing in another sport ◦ Stretching

5.4.2.1 Their is no association between ***age*** and swimming injuries.

Rejected

5.4.2.2 Their is no association between ***gender*** and swimming injuries.

Accepted

5.4.2.3 Their is no association between ***ethnic group*** and swimming injuries.

Accepted

5.4.2.4 Their is no association between taking part in ***other forms of exercise*** and sustaining a swimming injury.

Rejected

5.4.2.5 Their is no association between sustaining an ***injury due to taking part in another form of exercise*** and swimming injuries.

Rejected

5.4.2.6 Their is no association between taking part ***competitively in another sport*** and swimming injury.

Accepted with caution

5.4.2.7 ***Sustaining an injury due to taking part in another competitive sport*** is not associated with swimming injury.

Rejected

5.4.2.8 Their is no association between eating a ***balanced diet*** and swimming injuries.

Accepted

5.4.2.9 Their is no association between not ***taking supplements*** and injury.

Accepted with caution

5.4.2.10 Their is no association between ***hereditary diseases and*** swimming injury.

Accepted

5.4.2.11 Their is no associations between ***Stretching*** and swimming injury.

Accepted

5.4.2.12 their is no associations between the ***age at which you started swimming*** and swimming injuries.

Accepted

5.4.2.13 Their is no association between the d***uration of swimming competitively*** and swimming injury.

Rejected

5.4.2.14 Their is no association between the ***number of hours swum per week*** and swimming injuries.

Rejected

5.4.2.15 Their is no association between the ***duration of each session*** and swimming injuries.

Rejected

5.4.2.16 their is no association between the ***distance swam per week*** and swimming injuries.

Rejected

5.4.2.17 Their is no association between the ***number of training sessions per week*** and swimming injuries

Rejected

5.4.2.18 Their is no association between the ***Rest time between sessions*** and swimming injuries.

Rejected

5.4.2.19 Their is no association between the number of ***hours of land training*** and swimming injuries.

Rejected

5.4.2.20 Their is no association between the number of ***hours spent stretching*** and swimming injuries.

Accepted with caution

5.4.2.21 Their is no association between the ***type of swimmer*** and swimming injuries

Rejected – As middle distance swimmers are associated with injury

5.4.2.22 Their is no association between the ***main stroke*** swum and swimming injuries.

Accepted

5.4.2.23 Their is no association between the ***use of training equipment*** and swimming injuries.

Rejected- as the use of bands is associated with injury

5.5 Conclusion

There were 101 participants that took part in this study, with a similar number of male (49.5%) and female (50.5%) swimmers. The age of the sample population was young, with a mean age of 16.7 years. In terms of racial grouping there were predominately more white participants than non-white participants. The most common main stroke was Freestyle (n=39), followed by Butterfly (n=22). The most common second main stroke was also Freestyle (n=37), followed by Butterfly (n=31). Majority of participants classified themselves as sprinters (78.2%).

In this study the mean age of starting swimming was 9.6 years; the mean number of years of swimming competitively was 6.7 years. The participants in this study swam between 2 and 11 swimming session per week, with a mean swimming training time of 11.1 hours per week. They swam between 2.5 and 85km per week, with a mean distance of 32.2km per week. Swimmers had a mean training time of 1.8 hours per day and a mean land training time of 2.9 hours per week.

The majority of swimmers in this study swam at a National level (38.6%), with a similar number of swimmers competed at Provincial level (24.7%) and International level (23.7%), only 12.8% of the swimmers swam at School's level.

Seventy nine percent (79.2%) of participants in this study did another form of exercise other than swimming. With gym (34.6%) being the most frequent form of exercise. Of the participants who did another form of exercise 35.4% had had an injury as a result of this exercise, of which 66.7% were prevented from swimming.

A large number of participants in this study competed in another sport besides swimming (n=70). Of the participants competing in other sports

53.6% report have been injured due to this sport. Of whom 83.8% were prevented from swimming.

The lifetime prevalence of swimming injuries in this study was 53.5% and the current prevalence of swimming injuries was 17.8%. Although the proportion of current injuries appeared to be comparatively low, it must be considered that the lifetime (past) injuries that have been reported in this study, took place over the swimmers career whereas the current injuries were reported at the time of completing the questionnaire. The most commonly injured site was the shoulder for both the lifetime injuries (70.4%) and the current injuries (61.1%).

Participants blamed over training as the main cause for the development of lifetime (past) injuries (33.3%), followed by stretching in 31.5% and insufficient warm up in 25.9% of cases. Poor technique (22.2%) was also identified as a perceived cause of injury. "Other" causes accounted for 22.2% of injuries. These included insufficient stretching, an intense training regime as well as hereditary and medical conditions. Freestyle and Butterfly were the activities during which the most injuries were sustained (38.9% and 35.2% respectively). The use of hand paddles were also identified as being associated with 33.3% of injuries. "Other" factors accounted for 16.7% of injuries. These included gym or land training and being injured while racing.

In comparison, this study identifies that 33.3% of participants blamed stretching for their cause of the current injuries. "Other" causes were also largely to blame in 33.3% these included; insufficient or the lack of stretching, poor training techniques, muscle weakness, an intense training regime, the use of hand paddles, tumble turns and dives, medical as well as hereditary conditions. Over training was identified as a causative factor for their current injury for 27.8% of participants.

Butterfly (38.9%) was identified as the activity during which the most current injuries were sustained, followed by the use of hand paddles (33.3%) and Freestyle (27.8%). "Other" causes included insufficient stretching.

Maintenance treatment was received by 17.8% of participants with Sports Massage (9.9%) being the most common treatment, followed by Chiropractic treatment (5.94%). However, in the treatment of their swimming injuries Physiotherapy was the treatment of choice for both the lifetime (past) (64.2%) and current injuries (50%). Chiropractic treatment was used by 26.4% of participants with lifetime (past) injuries and 27.8% with current injuries.

In this study 14 risk factors were inserted into this model, of which there were only 4 risk factors that were shown to be ***independently significantly*** associated with swimming injuries. These included: having sustained an injury from another form of exercise; competing in another sport; the amount of time spent swimming training and number of swimming sessions swum per week.

There appeared to be some trends in associations between these risk factors and injuries. The amount of time spent swimming training and the number of swimming session per week appeared to be the most statistically significant, with a p value of < 0.001, followed by the amount of rest between sessions ($p=0.001$).

Increasing age, injuries due to another sport or from exercise, increased number of hours spent doing land training, competing in another sport, the number of years of swimming experience, the distance swum per week, the use of a band during training and being a middle distance swimmer were also found to be significant risk factors for the development of swimming injury.

Chapter 6

Conclusion and Recommendations

6.1 Introduction

This Chapter incorporates a summary of the results of the study. Conclusions about the results are drawn, and recommendations are provided for future studies based on the results as well as the limitations of this study.

6.2 Conclusions

The overall prevalence of ever sustaining an injury due to swimming was relatively high (53.5%). The shoulder was the site where injury was most likely to occur. The independently significant risk factors associated with injury were previous injury due to another form of exercise or sport, duration and number of sessions swum per week.

Due to the cross sectional design of this study it is not clear whether these risk factors were present before the swimming injury occurred, or merely presented concurrently with the injury. Therefore it is stated that causality and reverse causality cannot be established as the temporal sequence of events was not established in the questionnaire. Thus further longitudinal studies are recommended to establish the temporal sequence of causal events for these independently significant factors.

All remaining factors (significant or insignificant) addressed in this study would require an increased sample size in order to determine whether they independent or dependent risk factors; as this study was unable in its current format to clearly delineate these relationships.

6.3 Recommendations

- To obtain a larger, more representative study with regard to ethnicity is needed in order to verify the association between ethnicity and swimming injuries; as it is currently assumed that statistics derived from Caucasian population studies are applicable to all ethnic groups.
- Further longitudinal studies are recommended to establish the temporal sequence of causal events for the participants who are injured. This would be to determine whether the risk factors were present before the swimming injury or were the cause of the swimming injury. So that definite causative factors for injuries would be established rather than associated with swimming injuries.
- Further longitudinal studies on the same sample group, in a approximately 10 years time (taking into account the duration of a competitive swimmers career) in order to see if they have a high risk of developing more injuries due to the fact that they may have a history of swimming injuries.
- To stratify the sample group by the distance they swim, the stroke they swim and the age of the swimmer in decreasing order of importance to attain a more concise profile of musculoskeletal injuries in the specific type of swimmer.
- To include an increased age range to compare the injury profile of elite competitive swimmers with Master's swimmers to determine if the risk factors and injury profile are uniform irrespective of age.
- To include more in-depth questions pertaining to swimmer's stretching habits and the number of hours spent stretching so that the association between the duration of time spent stretching and swimming injuries can be highlighted.
- To include more in-depth questions regarding the use of supplementation in order to identify whether there is an

association between the use of supplements and swimming injuries.

- Areas for future research based on causal association in the results of this study. Age versus distance swum; Age versus session swum per week and Age versus breathing technique.
- Coaches needs to monitor repetitive strain injuries closely ensuring that the swimmer receive appropriate care both from a curative and a preventative vantage point.

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APPENDIX A1

Dr Ingrid Adamson M.Tech: Chiro (DUT)

Registered Chiropractor
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Tel: (031) 2011442
Cell: 0827192437
Practice no. 0040000217867

10/05/2007

To whom it may concern

I hereby give my written consent to Kelly Sutherland for the use of a modified version of my gymnastics injuries questionnaire in her research.

Yours sincerely
Dr Ingrid Adamson

Adamson

APPENDIX A2

Durban Institute of Technology: Department of Chiropractic

Gymnastics injuries in the greater Durban area: A quantitative profile of competitive athletes.

The Gymnastics Injury Questionnaire.

Gymnast	Coach/Judge	Administrator

Please place a cross in the appropriate box. Please answer all the questions.

Section 1: Personal information

1. What is your sex?

Female	Male

2. Which ethnic group do you belong to?

Black	White	Coloured	Asian

3. What is your age (in years)?

years

4. What other exercise do you perform on a regular basis (ie at least twice a week)?

5.Do you take part in any other competitive sporting activities? If yes, please specify your two primary activities other than gymnastics.

---

6. Please state your worst two injuries from the sports mentioned in question 6.

_____

_____

7. Do you eat a balanced, healthy diet?

Yes	No

8. Do you take any supplements?

Yes	No

Section 2: Gymnastics History

9. At what age did you start gymnastics? _____ years

10. At what age did you start competing in gymnastics? _____ years.

11. How many years experience do you have in gymnastics? _____ years.

12. At present, how many hours do you train in the gymnasium per week?

4-8 hours	9-13 hours	14-18 hours	19-23 hours	24 hours or more

13. At present, how many gymnastics classes do you attend per week?

7 0r more	6	5	4	3	2	1

Section 3: Previous gymnastics injuries

14. Have you **ever** sustained an injury from gymnastics?

Yes	No

15. Have you ever received regular treatment from any of the below, to keep your body in good condition, even if you have never sustained an injury?

Rehabilitation	Medication/injections
Orthopaedic	Chiropractic
Bracing/strapping	Home remedies eg. ice
Physiotherapy	Nutritional therapy
	Natural therapy eg. homoeopathy

If your answer to question 14 (above) is "No", please move on to Section 4.

16. How often have the following areas of your body been injured during gymnastics? (This includes any injuries from gymnastics sustained at any time during your gymnastics career).

Seldom: once or twice

Often: 3 to 5 times

Very often: More than 5 times

A. Foot/toes	Very often	Often	Seldom
B. Ankle	Very often	Often	Seldom
C. Achilles tendon	Very often	Often	Seldom
D. Leg (calf/shin)	Very often	Often	Seldom
E. Knee	Very often	Often	Seldom
F. Hamstrings (back of thigh)	Very often	Often	Seldom
G. Quadriceps (front of thigh)	Very often	Often	Seldom
H. Hip/groin	Very often	Often	Seldom
I. Low back	Very often	Often	Seldom
J. Upper back	Very often	Often	Seldom
K. Neck	Very often	Often	Seldom
L. Head	Very often	Often	Seldom
M. Shoulder	Very often	Often	Seldom
N. Biceps (front of upper arm)	Very often	Often	Seldom
O Triceps (back of upper arm)	Very often	Often	Seldom
P. Elbow	Very often	Often	Seldom
Q. Forearm	Very often	Often	Seldom
R. Wrist	Very often	Often	Seldom
S. Hand	Very often	Often	Seldom
T. Other	Very often	Often	Seldom

If "other", please specify: _____

17. Consider the worst injury (noted in the above table) that you have sustained during gymnastics. How would you describe the severity of this injury?

Mild	Moderate	Severe

From the list above (Q. 16 A-T), please state the area that was worst injured:_____

18. How have injuries to any of the areas listed below affected your gymnastics?

A. Foot/toes	Prevented gymnastics	Limited gymnastics	No effect
B. Ankle	Prevented gymnastics	Limited gymnastics	No effect
C. Achilles tendon	Prevented gymnastics	Limited gymnastics	No effect
D. Leg (calf/shin)	Prevented gymnastics	Limited gymnastics	No effect
E. Knee	Prevented gymnastics	Limited gymnastics	No effect
F. Hamstrings (back of thigh)	Prevented gymnastics	Limited gymnastics	No effect
G. Quadriceps (front of thigh)	Prevented gymnastics	Limited gymnastics	No effect
H. Hip/groin	Prevented gymnastics	Limited gymnastics	No effect
I. Low back	Prevented gymnastics	Limited gymnastics	No effect
J. Upper back	Prevented gymnastics	Limited gymnastics	No effect
K. Neck	Prevented gymnastics	Limited gymnastics	No effect

L. Head	Prevented gymnastics	Limited gymnastics	No effect
M. Shoulder	Prevented gymnastics	Limited gymnastics	No effect
N. Biceps (front of upper arm)	Prevented gymnastics	Limited gymnastics	No effect
O. Triceps (back of upper arm)	Prevented gymnastics	Limited gymnastics	No effect
P. Elbow	Prevented gymnastics	Limited gymnastics	No effect
Q. Forearm	Prevented gymnastics	Limited gymnastics	No effect
R. Wrist	Prevented gymnastics	Limited gymnastics	No effect
S. Hand	Prevented gymnastics	Limited gymnastics	No effect
T. Other	Prevented gymnastics	Limited gymnastics	No effect

If "other", please specify: _____

_____

19. What is the longest period for which you were not able to do gymnastics due to the injury mentioned above?

Greater than 6 months	3-6 months	Less than 3 months

Section 4: Present gymnastics injuries

20. Are you **presently** suffering from an injury due to gymnastics? **(If the answer to this question is "No", please move on to section 5).**

Yes	No

21. If you currently have more than one injury, please specify how many: _____

22. Which part of your body is **most** injured at the moment?

A. Foot/toes	L. Head
B. Ankle	M. Shoulder
C. Achilles tendon	N. Biceps (front of upper arm)
D. Leg (calf/shin)	O. Triceps (back of upper arm)
E. Knee	P. Elbow
F. Hamstrings (back of thigh)	Q. Forearm
G. Quadriceps (front of thigh)	R. Wrist
H. Hip/groin	S. Hand
I. Low back	T. Other
J. Upper back	
K. Neck	

If "other", please specify: _____

23. How would you describe the severity of this injury on a scale of 1 to 10? (0 represents no pain, and 10 represents severe pain).

1	2	3	4	5	6	7	8	9	10

24. At the moment, how does your present injury affect your gymnastics?

Prevents gymnastics	Severe limitation and pain	Some limitation	Some pain	No effect

25. What is the longest period for which you were not able to do gymnastics due to your present injury?

Greater than 6 months	3-6 months	Less than 3 months

26. How long have you had your present injury?

Greater than 6 months	3-6 months	Less than 3 months

27. Which of the following factors do you feel is the most likely cause of your present injury?

Insufficient warm-up/cold	Equipment failure
Stretching	Difficult movements
Overstretching	Repetitive movements/landings
Jumping	Team/group work
Incorrect landings	Falls
Insufficient rest/overwork	Collisions
Incorrect posture/placement	Twisting
	Other

If "Other", please specify: _____

28. During which activity was your present injury sustained?

Warm-up/stretching		Beam		Using hand apparatus	
Vault		Parallel bars		Conditioning	
Horizontal/asymmetric bars		Rings		Strength training	
Floor/dance work		Pommel horse		Unsure	

29. Has anyone ever pointed out a weakness in your gymnastic technique?

Yes	No

If so, please describe **briefly** (for example, you always work with an arched back, or you bend your legs in everything you do):

_____

_____

Section 5: Treatment

30. Have you **ever** received treatment for a gymnastics injury?

If your answer to this question is "No", please leave out the rest of the questionnaire.

Yes	No

31. What type/s of treatment have you received for your past injury?

Rehabilitation		Medication/injections	
Orthopaedic		Chiropractic	
Bracing/strapping		Home remedies eg. ice	
Physiotherapy		Nutritional therapy	
		Natural therapy eg. homoeopathy	

32. Have you received treatment for your **present** injury?

Yes	No

33. What kind of treatment have you received for your present injury?

Rehabilitation		Medication/injections	
Orthopaedic		Chiropractic	
Bracing/strapping		Home remedies eg. ice	
Physiotherapy		Nutritional therapy	
		Natural therapy eg. homoeopathy	

APPENDIX A3

Section 1: Patient Information

1. Age in years? | Years |

2. What is your sex?

Male	Female

3. Which ethnic group do you belong to?

Black	White	Coloured	Asian	Indian

4.what other exercise do you do on a regular basis besides swimming (i.e. twice a week.)?

.....
.....
.....

5. Do you compete in any other sport besides swimming? If yes, please specify.

.....
.....
.....

6. Please state your worst two injuries form the sport mentioned in question 5.

.....
.....
.....

7. Do you eat a balanced diet?

Yes	No

8. Do you take any supplements?

Yes	No

9. If you answered yes to question 8, please specify what supplements you are taking.

.....
.....
.....

Section 2: Swimming History

7. At what age it you start swimming? ..... Years.

8. How many years have you been swimming competitively?
.....Years.

9.At present how many hours per week do you train swimming?
.....

9.At present how many hours per week of land training to you do?
.....

10.On average how many kilometres do you swim per week?
.....

11. What is your main stroke?

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

12. What is your second main stroke?

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

13. Would you classify yourself as?

Sprinter (50 /100m)	Middle distance swimmer (200 /400m)	Long distance swimmer (800 / 1500m +)

13. What is your main event?
.....
.....

14. What is your second main event?
.....
.....

15. What other events do you swim?
.....
.....

16. What is the highest level at which you have competed?
.....
.....

Section 3: Previous Swimming Injuries

17. Have you **ever** sustained an injury due to swimming?

Yes	No

18. If yes, identify the injury? (I.e. was it acute or chronic, was traumatic or a repetitive strain injury?)

.....

.....

19. Do you **currently** have any injuries due to swimming?

Yes	No

20. If yes, please identify the injury.

.....

.....

21. Have you **ever** received treatment for your swimming injury?

Yes	No

22. If yes, what type of treatment did you receive?

Bracing / strapping		Medication/ injections	
Orthopaedic		Home remedies eg: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Natural therapy eg: Homoeopathy	
Rehabilitation		Other	

If "Other", please specify:

.....

.....

23 .How often have the following areas of your body been injured while swimming?
(This includes any injuries from swimming sustained at **any time during your swimming career.)**

Seldom- once or twice
Often- 3-5 times
Very Often- more than 5 times

A. Foot/ toes	Very often	Often	Seldom
B. Ankle	Very often	Often	Seldom
C. Achilles tendon	Very often	Often	Seldom
D. Leg (calf/ Shin)	Very often	Often	Seldom
E. Knee	Very often	Often	Seldom
F. Hamstring (front of leg)	Very often	Often	Seldom
G. Quadriceps (back of leg)	Very often	Often	Seldom
H. Hip / Groin	Very often	Often	Seldom
I. Lower Back	Very often	Often	Seldom
J. Upper Back	Very often	Often	Seldom
K. Neck	Very often	Often	Seldom
L. head	Very often	Often	Seldom
M. Shoulder	Very often	Often	Seldom
N. Biceps (front of upper arm)	Very often	Often	Seldom
O. Triceps (back of upper arm)	Very often	Often	Seldom
P. Elbow	Very often	Often	Seldom
Q. Forearm	Very often	Often	Seldom
R. Wrist	Very often	Often	Seldom
S. Hand	Very often	Often	Seldom
T. Other	Very often	Often	Seldom

If "Other", please specify:
.....
.....

24. Consider the worst injury that you have sustained during swimming. How would you describe it?

Mild	Moderate	Severe

From the list above (Q. 22 A- T) please state the area that was injured the worst:
.....
.....

25. How have the injuries listed below affected your swimming?

A. Foot/ toes	Prevented swimming	Limited swimming	No effect
B. Ankle	Prevented swimming	Limited swimming	No effect
C. Achilles tendon	Prevented swimming	Limited swimming	No effect
D. Leg (calf/ Shin)	Prevented swimming	Limited swimming	No effect
E. Knee	Prevented swimming	Limited swimming	No effect
F. Hamstring (front of leg)	Prevented swimming	Limited swimming	No effect
G. Quadriceps (back of leg)	Prevented swimming	Limited swimming	No effect
H. Hip / Groin	Prevented swimming	Limited swimming	No effect
I. Lower Back	Prevented swimming	Limited swimming	No effect
J. Upper Back	Prevented swimming	Limited swimming	No effect
K. Neck	Prevented swimming	Limited swimming	No effect
L. head	Prevented swimming	Limited swimming	No effect
M. Shoulder	Prevented swimming	Limited swimming	No effect
N. Biceps (front of upper arm)	Prevented swimming	Limited swimming	No effect
O. Triceps (back of upper arm)	Prevented swimming	Limited swimming	No effect
P. Elbow	Prevented swimming	Limited swimming	No effect
Q. Forearm	Prevented swimming	Limited swimming	No effect
R. Wrist	Prevented swimming	Limited swimming	No effect
S. Hand	Prevented swimming	Limited swimming	No effect
T. Other	Prevented swimming	Limited swimming	No effect

If " Other", please specify:

.....

.....

26. Has your injuries **ever** caused you to stop training?

Yes	No

27. What is the **longest period**, which you were unable to swim due to the above-mentioned injury /ies?

Less that 3 months	3-6 months	Greater than 6 months

Section 4: Present Swimming Injuries

28. Are you **presently** suffering with any injuries due to swimming?

Yes	No

29. If you answered yes to Q27 please specify the injury.

.....
.....
.....

30. How would you describe to pain on a scale of 0 to 10 (0 represents no pain and 10 represents severe pain.)

0	1	2	3	4	5	6	7	8	9	10

31. At this moment how does your **present injury** affect your swimming?

Prevents swimming	Severe limitation & pain	Some limitation	Some pain	No effect

32. What is the longest period this **present injury** has prevented you from swimming?

Less that 3 months	3-6 months	Greater than 6 months

33. How long have you been suffering with this injury?

Less that 3 months	3-6 months	Greater than 6 months

34. What do you feel is the most likely cause for your injury?

Insufficient warm-up		Over training	
Stretching		Insufficient rest	
Gala		Poor nutrition	
Other			

If " Other", please specify:

.....

.....

35. During which activity was your present injury sustained?

Warm-up		Diving	
Tumble turns		Pulling	
Kicking		Fin work	
Paddles		Drills	
Other			

If " Other", please specify:

.....

.....

36. Have you ever received stroke correct?

Yes	No

APPENDIX B

LETTER OF INFORMATION

(Focus Group)

Dear Participant,

Welcome to the focus group of my study. Thank you for your interest.

The title of my research project is:
A Profile of injuries in Competitive swimmers in the greater Durban Area

Name of supervisor: Dr. C. Korporaal (031-2042094)

Name of Research Student: Kelly Sutherland
(031-2042205 / 083 777 3632)

Name of Institution: Durban University of Technology

The purpose of this focus group is to validate the use of the Swimmers Injury Questionnaire in terms of gathering information from swimmers. You are asked to assist with the development of the questionnaire through use of this focus group, by means of discussing the questions and their ability to answer the research question as indicated under the title above. The discussions will focus on the changes that are necessary in order to alter the Swimmers Injury Questionnaire in order to convert the Questionnaire into a more accurate tool.

Thus your participation is much appreciated and it is assured that your comments and contributions will remain confidential. You are at any point permitted to disagree, however if this is the case, please give your reasons for this, as it will assist in the research process. The results of this focus group will only be used for research purposes.

Thank you for your participation,

Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)

Dr. C. Korporaal
(Supervisor)

APPENDIX C

Informed Consent/Assent Form
(To be completed by members of the Focus Group)

Date: 26 March 2007

Title of research project is:
A Profile of Injuries in Competitive Swimmers in the Greater Durban Area

Name of supervisor: Dr. C. Korporaal (031-204 2094)

Name of Research Student: Kelly Sutherland
(031-2042205/ 083 77736 32)

Name of Institution: Durban University of Technology

Please circle the appropriate answer

1. Have you read the patient information sheet? YES/NO
2. Have you had opportunity to ask questions regarding this study? YES/NO
3. Have you received satisfactory answers to your questions? YES/NO
4. Have you had an opportunity to discuss this study? YES/NO
5. Have you received enough information about this study? YES/NO
6. Who have you spoken to regarding this study?
   _____
7. Do you understand the implications of your involvement in this study? YES/NO
8. Do you understand that you are free to withdraw from this study? YES/NO
   a) At any time?
   b) Without having to give a reason for withdrawing?
   c) Without affecting your future health care?
9. Do you agree to voluntarily participate in this study? YES/NO

IF YOU HAVE ANSWERED NO TO ANY OF THE ABOVE, PLEASE OBTAIN THE NECESSARY INFORMATION FROM THE RESEARCHER AND / OR SUPERVISOR BEFORE SIGNING. THANK YOU.

PLEASE PRINT IN BLOCK LETTERS

Focus Group Member _____ Signature_____

Witness's name _____Signature_____

Researcher's name _____Signature_____

Supervisor's name _____Signature_____

APPENDIX D

CODE OF CONDUCT

(For members of the Focus Group)

This form needs to be completed by every member of the Focus Group prior to the commencement of the focus group meeting.

As a member of this committee I agree to abide by the following conditions:

1. All information contained in the research documents and any information discussed during the focus group meeting will be kept private and confidential. This is especially binding to any information that may identify any of the research process.

2. None of the information shall be communicated to any other individual or organisation outside of this specific focus group as to the decisions of this focus group.

3.The information of this focus group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Member Represents	Member's name	Signature	Contact details

APPENDIX E

CONFIDENTIALITY AGREEMENT

(Focus Group Declaration)

IMPORTANT NOTICE: THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE FOCUS GROUP, BEFORE THE FOCUS GROUP MEETING CONVENES.

1. All information contained in the research documents and any information discussed during the focus group meeting will be kept private confidential. This is especially binding to any information that may identify any of the participants in the research process.

2. The patient files will be coded and kept anonymous in the research process.

3. None of the information shall be communicated to any other individual or organisation outside of this specific focus group as to the decisions of this focus group.

4. The information from this focus group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Member Represents	Member's name	Signature	Contact details

APPENDIX F

Focus Group Transcript

Hi everyone thank you very much for coming this evening.

The purpose of the focus group is for you to help me have a look at the questionnaire that I had developed and to get your input on the questions. As you can see the title of my research is A Profile of Injuries in Swimmers.
I'm looking at swimmers as the populations group and what factors affect the swimmers like the age of the swimmer, race, sex, distance, stroke, those kinds of things, lack of nutrition. Have any affect on the injury they have. If you can give me any input that you feel is relevant for the questionnaire and if possible to give answers that would help.

Basically the first section is just the patient's information; I've asked age of patients, sex, and ethnic group.
Then I've asked what other exercise do you do on a regular basis besides swimming to rule out...?
Shouldn't you rather ask gender instead of sex for question 2, as otherwise might get some funny answers? Yes Please...
Ethnic group is that ok? Black, White, Coloured, Indian ...
Do you want to put other just in case? There is somebody who doesn't fit those five.
What other exercise do you do on a regular basis? Is that ok?
What do u mean by exercise?
Well a sport, gym, any sport that they may compete in other than swimming. Rugby, waterpolo, cricket to make sure there was no.....to rule out.....
Biggest combination is going to be swimming with gym work....
Exercise including weight training or something like that in brackets.
Twice a week bracket at the end does it mean twice a week swimming or twice a week exercise?
Twice a week exercise besides swimming.
The way it is written there it can be interpreted as the swimming you do twice a week, than everything you might do.
Maybe you should put it after on a regular basis.
Question 4 is okay?
Do you compete in any other sport besides swimming? If yes specify
Please state the 2 worst injuries from the sport mentioned in 5?
From is spelt wrong.
Do you eat a balanced diet?
Going back to questions 4 and 5 will they know the difference between exercise and sport?
Must I put exercise / sport?
I'm just pondering whether they'll give the same answer for both those questions? Or potential can do?
You often do weight training with gym and sport on top of that.
Do question 4....
Spinning, weight training, gym under exercise and sport would be rugby, cricket waterpolo under sport
What sport are you looking at?
Elite, Competitive.
They not go to play any other sport at school. Like netball.
A lot of them play waterpolo
Cause you can get a broken finger from waterpolo,
Put question 4 as gym exercise
You can still play and not train, just play matches.
But you can still get injured.
Ya you can.
Question 5 as Sport as rugby waterpolo.
I should have 2 questions 1 for sport and 1 for exercise.
Yes. So you will have two distinct questions.

Then I should put the same for question 6, and then I should have for question 4 as well.
4 and 5.
Maybe you should put them in a block. Question 4 and two options and question 5 and 2 options. Instead of just a line.
Worst two injuries from number 4 and the worst two injuries from number 5
Okay, so I should do question a and b?
Otherwise they going to give you the worst two injuries without telling you were they from.
Do you eat a balanced diet?
Might have to you say in your opinion. Because you may not eat very much but you might eat well she eats well.
That is balanced.
Would it be worth asking people whether they are vegetarian/ Non- vegetarian?
Protein....
It might be for nutritional probably could be quite good idea.
But you don't want to go into to much detail you already going to have a lot and it's a touch subject....
Under supplements should I specify protein shake, vitamins?
Maybe you should make a list of things of potential things with a yes/ no column, so they can tick. Maybe they have a protein shake and a multi vitamins.
Then you can dispense question 9.
What else would you say? Protein shake, vitamins...
Creatine
Other, Specify
Also if you looking at supplements, capsules versus injectable, like vitamin B. One you take or the other you have to go to someone to get. People might not think that a vitamin B injection is a supplement but it is a...
So self med versus seeing a doctor.
Other and please specify.
Staminade, the energy drink you use during training,
Creatine, Protein, the main ones.
Just have 5 things, the main things protein shake, vitamins, Creatine, vitamin B injections.
You don't want to make things to complicated.
Rule out number 9
So then under question 8 I must just go, supplements yes /no then a column

And then the next section is swimming history.
What age did you start swimming?
Is there anything else?
Competitive swimming,
Is there anything else with respect to you guys as swimmers do you think could potentially predispose you to injuries?
Preventative stuff...like stretch cords
That could come later.
In terms of you yourselves with respect to swimming?
Outside of jumping in the pool, is there anything else that could predispose you to injury?
You don't what to know family History wise,
Medical problems, some sort of scoliosis?
Any know family history
Heart disease, high cholesterol, diabetes...
If you're clever, you'll put them into categories...Ya
But you want things that will predispose you to injury.
Like arthritis, scoliosis...
You might want a question on family and self.
Ya,
Musculoskeletal
Surgery you've had
Previous injuries...
We'll discus it when we get there, have you had any injuries/ surgeries
Arthritis, Scoliosis,
That will go in section 1.

Anything else that you think is needed in patient information?
If there is anything more we can always go back.
Ok with regards to swimming history
Age, you started competitive swimming
Question 8 number of years you have been swimming competitively.
Isn't that the same?
No, cause they may not have swam consecutively.
Or only swam competitively after the first 5 years
Also to cross reference.
At present how many hours do you train?
I don't know how many hours
Average.
How many hours per week land training do you do?
The average hours per week
In brackets maybe put gym?
No most swimmers know what land training is.
Question 10, on average how many kilometres do you swim per week?
What is your main stroke?
What is your 2nd main stroke?
What do you classify your self as?
Open water swimmer?
I'm looking generally at pool swimmers as apposed to open water swimmers.
But you may find a lot more open water swimmers with shoulder problems.
They do both.
Maybe put a column after long distance swimmer, have open water > 1km, because most swimmer will swim open water events, as well.
Most swimmers do both, Midmar >1km.
Generally sea, lakes...
Then they will obviously just tick the ones they are
Can the tick more than one?
Yes
Do you want to say where they can tick more than one and where they can only tick one?
11 and 12 they can only tick 1.
Some people swim like 100m fly, 400m free.
They generally swim more than one main event.
Main events and secondary events
Maybe they must put 2 events for each
Second main is also 2 events.
What is the highest level at which you have competed.
Is it not easier to give them a list of options?
Schools, Provincial, National, International.
How many races do you swim at galas and stuff, you might swim a gala every weekend?
Amount of races you swim?
Number of galas per month
Per month is better.
On average.
Some people swim every race and other people swim only 1 race at a gala.
Maybe you should put how many races do you swim?
Okay, we should do both.
So I should have number of galas and then number of races per gala?
Anything I've left out with regards to swimming history
Swimming equipment?
Like kick boards and stuff.
I think I've put that further along.

Section 3 is previous swimming injuries
Q17 Have you ever sustained an injury during swimming?
Yes, identify the injury
Acute, acquired, traumatic,
They may not know the injury.

At best they'll be able to tell you my shoulder was sore.
Maybe say a long term injury, something easier.
Shorten it, like long term,
Do you currently have any injuries due to swimming?
More lines...
Specify, excluding stubbed toes
Stretching for section 2?
Like how much time do you spend warming up?
Stretching, over here some where
Before/ after training?
Apparently they say if you stretch before swimming you get little tears and stuff. So they say is best to stretch after swimming?
It's good to warm up before you stretch.
So when do you do it.
Questions 17 and 19 do you want any old injury or an injury that was sustained from continuing swimming or training sessions?
Well any injury that they sustained due to swimming. Whether it's been...
I was just thinking of the stubbed toe.
Maybe you should put major injuries/ or injuries that prevent you from swimming.
Injuries that affected your swimming.
But, Swimmers generally swim through.
Ya...
But if they've got a broken bone or something
You'd be surprised, they would swim through
Just kick or something...
You'd have to swim...
You would swim through
Identify the injury or define the injury in such a way that they know a stubbed toe isn't what you are looking for.
Is it not easier to just when I'm talking to them, tell them that i
Swimming related
Swimming related injuries not a stubbed toe
I don't think a stubbed toe would be swimming related?
Well you can kick your foot on the bottom of the pool.
Ultimately in my mind you are looking for the major, you might just need to think of a definition that you can stick at the beginning of that. Injury defined as, get around defining a major injury.
Like tendonitis
But they won't like of tendonitis as a major injury.
Maybe you should say an injury to your tendons, muscles, ligaments or bones.
Stubbing your toe is still an injury to any of the above?
Is it still not easier for me to say when I'm handing out the questionnaires that them I'm looking for the big injuries, I'm not looking for the stubbed toe or the.
But you are not necessarily going be there every time.
Let's write it down and when you get the results just cancel it out.
The problem is they might think a stubbed toe is but not something you really want.
All Injuries...
Maybe you should say, all injuries excluding minor injuries and scratches.
Think about that one...
21 have you ever received treatment for your swimming injury?
Which one 18 or 20?
Both
Swimming injury
Do I need to specify, have two questions?
Perhaps you should put previous injuries...
Then repeat it...
Put the same table...
So repeat and put it in section 4
Then question 22
I presume they can tick more than one?

Surgery?
That would fall under orthopaedic, so put orthopaedic/ surgery.
Any other treatment you can think of that I've left out?
Question 23 how often have the following areas of your body been injured?
This includes any injury from swimming sustained at any time during your swimming career.
Question 22 does that only pertain to current injuries?
Yes, but I said I'd put a block under question 18 as well.
Add a block, the same table under 18 and then 21 and 22.
Have you thought about like some people go for massages once a week or go to the Chiropractor to get adjusted?
Maintenance treatment.
Ya... ...
That helps prevent you injuries like going to physio or chiro to be treated.
Maybe you should add that in and stick it with you stretching questions.
Preventative measure...
Up at the top?
I don't know were you have your preventative things.
I haven't done one...
Like under the warming up question.
After the stretching...
Any regular maintenance treatment
Like massage, or seeing chiropractors?
These will all go under section 2.

Does that make sense?
Seldom, once or twice, often 3-5 times very often 5 or more time?
Then I've just listed them.
I think you should highlight seldom, often, very often.
Month a year??
Ever.
Definitely highlight,
Then I think remove the seldom...from the columns
Then obviously you can tick as many as you like.
Then maybe you should state that.
Then I've just listed everything...head, shoulder, elbow...
'Other' if they can think of any more.
Then consider the worst injury you've ever sustained from swimming. How would you describe it, mild moderate, severe?
Then from the list above.
Below...
No, above the one with A-T. Please state the area that was worst affected.
Maybe you should say areas, maximum 2?
Maybe you should put that before you enter your mild, moderate, and severe?
From the list above, which are the 2 worst and how would you rate them?
Yes.
How have the injuries listed below affected your swimming?
A-T again, prevented swimming, limited swimming, or had no effect.
Question 26 has your
Have your injuries
Have your injuries ever caused you to stop training? Yes/ no
What is longest period you were unable to swim due to the above injuries?
Less than, not less that.
May be you should word it along the lines of; if you ever had an injury that prevented swimming, in 25 did it ever stop you from training. If they said it prevented swimming in question 25 did it also stop them from training?
Isn't prevented swimming and stopped training the same thing?
I don't know?
Prevent swimming and stopped training?
Not necessarily because maybe you can't swim but they still training.
You may not be swimming galas but you still paddling up and down the pool.

Maybe you should ask if you trained through it. And what sort of training you've done. If you still training swimming like just like legs or stuff like that, like if I had an injury I would still running or stuff like that. Or kick
If you had an injury did it stop swimming completely?
Did the injury stop you from training completely?
Or doing or routine set
If it's stopping competitive swimming then it's the same as question 25, in my mind. I'm just trying to establish what you want in 25 and what you want in 26
I don't really know...
Because there to be a difference between preventing swimming which I'm assuming is prevent gala, or preventing training. Then you need to have a distinct difference between the two. If there isn't then you maybe
Need to define training?
Training would be anything from your land training to your stretch to your swimming training ... but your prevented swimming also be only your pool work appose to your galas
That would still make them the same
Maybe you should have a big block or something that says prevent swimming, because some are just a week, or a month...
Yes...
Some like the shoulder you only kick so your swimming is limited but you haven't stopped all together...
Maybe you don't need to unless to want to say prevent swimming...
Ya...
Unless if you want to find out what the limitation is, then in the limitation block they will have to indicate what it is they are doing or not doing.
Ya...
Okay, so limited being what they can do?
Were you able to kick or were they able to do...
They can tick the prevented swimming.
Under limited the must specify.
They must say what the limitation is they can't kick they can't...
So if the injured there shoulder they must specify like kicking...
So if they tick the limitation category they have to specify what the limitation is.
Maybe you should say that before the table, if you tick limited please specify.
Okay, then obviously make the block wider...
Make they block one tab bigger so they can write in the block.
Then delete 26.
And 27 okay?
Or do you think I should put...
Maybe you should say if your injury prevented swimming what was the longest period for which you were unable to swim.
Maybe specify the injury as well, like the neck might be ...
Do you not want week as well?
Less that 3 months should be fine.
What about a week or two weeks
Some injuries are a week some are 3 days...
Under a month.
Less than one month.
Ya
Just a question what is the difference between question 28 and 19?
They were the same; it was to cross check... I don't know if I have to word it differently...
Because they will page back and give you exactly the same answer.
That's good then I know that they are not lying.
I don't think you need to cross check.
I would take the first lot out, because then section 3 is just to do with previous swimming and section 4 to do with present injuries.
Then if they haven't had a previous injury they can leave out the whole section.
They can leave out the whole section.
They can just cross no and then leave out the rest of the section.
So leave out question 19.

And 20 that goes with it.
So then moving into section 4.
And then I'll still put 21 and 22 with 19 and 20?
That whole section anything related to past injuries will stay, ya
You still want to know if they've received treatment, blah blah blah.
And then you can say if you've answered no then you can move to section blah blah...

Then do you want to put in what your worst injury is.
Yes, then 19 and 20 would move to were question 28 is.
Potentially 19, 20, 21 and 22.
Then remove 29,
Yes.
I'm confused 19, 20...
Okay... don't worry I'll sit and make out what's going on.
My spelling check was very bad.
No your spell check was good you just chose the wrong words.
Okay...
Question 30 is how would you describe the pain on a scale of 0 to ten with 0 being no pain and 10 representing severe pain.
You want to restructure it so the scale is on the same page.
Stay on the same page.
Considering we've removed 4 questions it might help.
Don't worry I will make sure of that.

Question 31 at this moment how does your present injury affect your swimming?
Again do you want to ask them what the limitation is if they tick a limitation one?
Yes, please specify.
We can leave the blank blocks out they can tick over the words and cross over the words.
Okay.
Explain...
Then I think I must add on ...
That was for previous injuries.
Ya, but you must add on the less than 1 month.
Okay.

How long have you been suffering with this injury?
Is that not the same as the previous question?
It's exactly the same.
No, not really, actually.
No because this one is how long have you had the injury and that one is how long have you suffered with the injury

No what is the longest period it has affected your swimming.
True.
Just don't forget to put in less than 1 month.
It's not less that it's less than.
Then I would put 33 before 32.
Question 34 what do you feel is the most likely cause of your injury?
Insufficient warm up; stretch; galas; overtraining; insufficient rest; poor nutrition.
Interesting thing is that you don't have that question under your previous injuries.
Should I move it?
Yes, and probably the next one as well.
Section 3
Poor technique,
Move 35 as well

Is there anything else that could cause an injury? Besides the ones that I've mentioned?
Over racings,
When you mean gala, do you mean gala frequency?
Well you can injury yourself at a gala, like your neck diving in.

It could be gala frequency or it could be at the event or while racing.
Would gala not fit into the other category?
Just let them tick other and write it in.
Because gala doesn't only mean one thing it can mean multiple things.
Yes, it can mean over racing.
Maybe you should put 2 gala frequency and gala injuries.
Injury at gala.
But I don't want them to say that they were injured because they were running around the pool and slipped.
Swimming injury from gala.
Maybe what it should be injury while racing.
Ya...
During participation injury and gala frequency, I don't know. Because at the moment gala by itself is too many things it could be.
Shouldn't instead of gala frequency, over competition or I don't know.
Over training or over racing?
Participation injury would be during the race and if they did slip and fell around the pool they can put that under 'other'.

Then during which activity was your present injury sustained?
Warm-up; tumble turns; kicking; paddles; diving; pulling; fin work; drills.
Maybe you should put other on the other side under drills.
Don't you want to ask what stroke it was?
Otherwise would it not be useful to merge the 3 cells so there is more space to write and delete the lines underneath.
Ya.
Put other with blocks?
No just merge the 3 cells into 1 long block and then they can write in there.
Then you can put please specify...
They also said stroke, so during which stroke did the injury occur in?
What stroke.
List the stokes all the strokes
Butterfly...
What about main set?
You sprint in your main set, because you've got warm-up.
Hell week, taper, also like... what stage in the cycle then say...
Hell week is the week of hard training.
Then say what hell week, taper, mid-cycle?
Taper or recovery...
Do I need to add stretch in as well?
Yes, stretching.
Anything else that you think of activity in swimming that could cause injury.
When up mean warm-up do you mean lack of warm-up?
During warm-up.
Lack of warm-up would fit into insufficient warm-up in the question above.
And then, there's no other things used?
Stretch cords; bands weight belts; snorkel.
You get all sorts of funny things.
You can get injured can up?
Yes you can use fins, paddles, snorkel and a weight belt.
You kidding,
Stretch cords you swimming away its hard. Then you come back swimming fast.
Then you need to add in all this stuff.
Parachutes.
Oh my word.
You don't want to know.
You get shorts with little pockets to increase resistance.
All sorts
That's hell week?
No that's every day...

That hell like...
So where does that fit in? You said main set.
I think those were just under your activities to add in.
Those ones weight belt.
Maybe say during use of swimming equipment or something like that.
Like would like to put specify.
Specify and be as specific as possible.
But it's important, because everyone is getting shoulder injuries because they training with certain equipment.
I'm trying to be as specific as possible.
Maybe you would like to add another question purely related to equipment, has the injury occurred with the use of.
There's lots of equipment.
What equipment do you use on daily basis?
Then injuries...Then they must specify everything that they use.
You might want to categorise weights as in whatever.
What equipment do you use during you're...?
Have you ever sustained an injury due to it?
So then do the blocks with all the... Have I left any out? I've got kick board; paddles; fins; pull buoy;
Weights; bands
I've got stretch cords; weight belts; bands;
Snorkel.
How often do you train a week?
I only know sessions.
Maybe 90km.
We train twice a day maybe 7.
8km a session.
16km per day?
How long does each session take?
Two and a half hours.
That means you train 5 hours a day then?
No about 25km per day.
It's going to be interesting to see the mileage they do.
That's going to be your biggest thing your mileage and your injuries.
We are made to do stretching exercises.
Sprinters do less. Where the long distances swimmer swim about a kilometre more per day, it's not much but it adds up.
What are you guys? Middle distance?
Yes, but we have different groups like I'm in the breaststroke group. And we do mainly breaststroke.

And then 34 and 35 and then this question about the equipment being used.
Stroke correction.
Would that not be better to put under your previous injuries? Whether they received any stroke correction from their previous injuries. As well as the current injury, if they got it for the pervious injury they shouldn't have the same injury again.
Do you think I should put the equipment use under previous injury as well? Under section 3.
Or should it just be one question?
What question are you going to ask? What equipment they use or have you asked...
I've asked what equipment they use during training.
Then you should just put it under the swimmers history part.
And then you want to ask...
Then I've asked have you sustained an injury due to the equipment.
You might want to put the first question under the general swimming questions and then the specify under the previous and the current injuries whether any equipment has been associated with the injury.
Or...
Then list them all...

The last question I've asked is the stroke correction question. Have you ever received stroke correction?
Everybody has.
We get stroke correction like every day. Our strokes are corrected all the time
But not every coach is like that.
Don't you want to put that in your history?
As appose to in the actual injury question.
Do you receive regular stroke correction?
You might want to define you regular, once a week.
Month?
Maybe you should rate the efficiency of their style, some people hack the water. Some people have a good stroke.
But that's all subjective, because you could hack the water and still feel that you are fantastic.
Coach will tell.
Have you ever been told that your technique is incorrect?
How often do you...
Some coaches don't care how you swim, as long as you get from A to B.
So do you think that I should just keep, do you receive regular stroke correction?
Yes.
Regular being on a monthly basis.
Or you can say at least once a month.
Something like that.

I think we just need to go back to the stretches and what not. And maybe put that under the swimming history. Whether they do regular stretching. That was brought up right in the beginning I'm just trying to find a place for it.
When they said the amount of time spending stretching per day.
Where are you?
No this is what I wrote down at the back to put into the section...
I would put that in section 2.
The other one was when do you stretch before or after training?
That would go in somewhere roughly after 16 or between your two 9's somewhere like that.
Nine a 1.
Should I put it up here, where I say how many hours a week do you train?
Yes where you talk about training.
Amount of training you doing, the amount of stretching you doing?

Is there anything else that you can think of that I've left out/

Do you want to know how often they train? I know you have the number of kilometres and hours. Like twice a day.
Or 3 sets per week.
Would that not come into your hours per day?
Some people might swim 6 hours straight while others may only swim for 2.
Maybe ask how many sessions a day.
Like sessions per day?
Session per week. She does 9 sessions a week. Rather than ask per day, because they might say 2 on 1 day and then 1 on an other day, then 2... So rather ask per week.
Yes.
Average hours.
How long is your average session?
How many sessions do you do per week on average?
Then how long is each.
Then definitely how long is each session.
So duration of each session?
Don't you ask like the break between each session? Some people have training in the morning and then in the afternoon. But some people who don't have school or that training now and then like an hour later.
To get it over with.

So you said duration of each session. Like 1 hour; 2 hours, etc. then you said number of sessions per week.
Average break between each session.
Average time between sessions.
So that would be giving you your rest period?
Just another question going back to question 5 and 6 do you want to know if any non swimming related injuries have prevented them from swimming?
I was just looking at the swimming injuries. That was what I was wanted to see. I did want to know about waterpolo...
I'm just asking because later on, like in 23 they may read the question and then answer it for any injury they've ever had. At least ask if the other sports injury prevented swimming you have a way of checking that they are not giving you the same in thing in the big block.
So bring it below question 5 if the weight training or sports has prevented then from swimming.
Yes, caused them to not swim.
Then must I say for the duration. As long as I know there was another injury.
Yes and if it prevented them from swimming.
Okay.

Areas of the body perhaps you should say right and left.
Just specify side.

Side you breathe
Or would you put in perceived causes/
I would put it under all the other thing related to swimming.

Is there any else in the questionnaire?
No.

Well thank you very much for your time and help I really appreciate it.
Please help yourselves to some snacks.

APPENDIX G (Pilot Study) Questionnaire no....

Durban University of Technology: Department of Chiropractic

A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area

Competitive Swimmers injury Questionnaire

Section 1: Patient Information

1. Age in years? [Years]

2. What is your gender? [Male] [Female]

3. Which ethnic group do you belong to?

Black	White	Coloured	Asian	Indian	Other (please specify)

4a. Do you do any other **exercise** (e.g. weight training/ gym/ spinning) on a regular basis (i.e. twice a week.) besides swimming?

[Yes] [No]

4b. If yes please specify.

.....

.....

5a. Have you ever sustained an injury due to the above mentioned exercise? (If no move to question 6)

[Yes] [No]

5b. Please state your worst **two injuries** from the exercises mentioned in question 4b.

.....

.....

6. Has the injury/s mentioned in question 4 prevented you from swimming for any period of time?

[Yes] [No]

7a. Do you **compete** in any other **sport** (e.g. waterpolo, hockey, cricket, etc.) besides swimming?

[Yes] [No]

7b. If yes please specify.

.....

.....

8. Please state your worst two injuries from the **sport(s)** mentioned in question 7b.

.....

.....

9. Has the sports injury/s mentioned in question 7 prevented you from swimming for any period of time? | Yes | No |

10. In your opinion do you eat a balanced diet? | Yes | No |

11. Do you take any supplements on a regular basis? | Yes | No |

	Tick
Protein Shake	
Multivitamins (please specify)	
Creatine	
Vitamin B injections	
Other (please specify)	

12. If you answered yes to question 11, please specify what supplements you are taking.

13a. To your knowledge are there any hereditary diseases in your family (e.g. Arthritis, Scoliosis, musculoskeletal diseases)? Which may affect your swimming at a competitive level. | Yes | No |

13b. If Yes please specify the disease(s)

.....

.....

Section 2: Swimming History

14. At what age did you start swimming competitively? | Years |

15. How many years have you been swimming competitively? | Years |

16. On average how many hours per week do you train swimming? | Hours |

17. What is the average duration of each swimming session? | Hours |

18. On average how many kilometres do you swim per week? | Kilometres |

19. On average how many sessions per week do you swim? | Sessions |

20. What is the average time (rest) between swimming sessions? Hours

21. On average how many hours per week of land training (gym) do you do?

Hours

22. On average how many hours per day do you spend stretching?

Hours

23. When do you usually stretch?

Before training	After training	Before and After training	Never

24. What is your main stroke? (Only tick one)

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

25. What is your second main stroke? (Only tick one)

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

26. Would you classify yourself as? (Can tick more than one)?

Sprinter (50 /100m)	Middle distance swimmer (200 /400m)	Long distance swimmer (800 / 1500m)	Open water swimmer (1km +)

27. What are your 2 main events do you compete in? (Include distance and stroke)

.....

.....

28. What are your 2 secondary events do you compete in? (Include distance and stroke)

.....

.....

29. What other events do you swim? (Include distance and stroke)

.....

.....

30. To which side do you breathe?

Left	Right	Bilateral

31. What is the highest level at which you have competed?

Schools	Provincial	National	International	Other

If other, please specify.

.....

.....

.....

32. On average how many galas do you swim in a season? | Galas per season |

33. On average how many races do you swim per gala? | races |

34a. Do you receive any maintenance treatment (for injury prevention) on a regular basis?

Yes	No

34b. If yes, please specify by ticking appropriate treatments below

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Homoeopathy	
Rehabilitation		Sports massage	
No treatment		Other (please specify)	

35. Do you receive regular **stroke correction**-at least once per month?

Yes	No

36. What equipment do you use on a regular basis while swimming training?

Kick board		Bands	
Pull buoy		Fins	
Weight belts		Parachutes	
Stretch cords		Paddles	
Snorkel			
Other (please specify)			

Section 3: Previous Swimming Injuries

37. Have you **ever** sustained an injury due to swimming? (If No please move to question 47)

Yes	No

38. If yes, name the injury? (Was it traumatic, a sudden injury or did it occur over a long period of time?) (tick the appropriate box/s)

	Name Injury	Traumatic or accident?	Sudden onset?	Over a period time?
1				
2				
3				
4				
5				

39. Have you **ever** received treatment for your swimming injury?

Yes	No

40. If yes, what type of treatment did you receive? (You can tick more than one treatment)

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Natural therapy e.g.: Homoeopathy	
Rehabilitation		Sports massage	
Other (please specify)			

41a .How often have the following areas of your body been injured while swimming? (This includes any injuries from swimming sustained at **any time during your swimming career.)**

(Please tick the appropriate columns)

	Area of body	**Seldom (once or twice)**	**Often (3-5 times)**	**Very often (more than 5 times)**
1.	A. Foot/ toes			
2.	B. Ankle			
3.	C. Achilles tendon			
4.	D. Leg (calf/ Shin)			
5.	E. Knee			
6.	F. Hamstring (back of leg)			
7.	G. Quadriceps (front of leg)			
8.	H. Hip / Groin			
9.	I. Lower Back			
10.	J. Upper Back			
11.	K. Neck			
12.	L. head			
13.	M. Shoulder			
14.	N. Biceps (front of upper arm)			
15.	O. Triceps (back of upper arm)			
16.	P. Elbow			
17.	Q. Forearm			
18.	R. Wrist			
19.	S. Hand			
20.	T. Other (please specify)			

41b. From the list above (Q.41 1-20) please state the area(s) that sustained the worst injured:

.....

.....

42. Consider the worst injury that you have sustained during swimming. How would you describe it? (Please tick the appropriate columns)

Mild	Moderate	Severe

43. How have the injuries listed below affected your swimming? (Please tick appropriate column and if they **limited your swimming** please will you **specify what you were able to do?** e.g. kicking)

	Area of body	**Prevented swimming**	**Limited swimming (specify)**	**No effect**
1.	Foot/ toes			
2.	Ankle			
3.	Achilles tendon			
4.	Leg (calf/ Shin)			
5.	Knee			
6.	Hamstring (back of leg)			
7.	Quadriceps (front of leg)			
8.	Hip / Groin			
9.	Lower Back			
10.	Upper Back			
11.	Neck			
12.	Head			
13.	Shoulder			
14.	Biceps (front of upper arm)			
15.	Triceps (back of upper arm)			
16.	Elbow			
17.	Forearm			
18.	Wrist			
19.	Hand			
20.	Other (please specify)			

44. What is the **longest period**, which you were **unable** to swim due to any the above-mentioned injury/s? (Please tick the appropriate columns)

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

45. What do you feel is the most likely cause for your injury? (Please tick the appropriate columns)

Insufficient warm-up		Over training	
Stretching		Insufficient rest	
Over racing		Poor nutrition	
Injured while racing		Poor Technique	
Other (please specify)			

46. During which activity was your injury sustained? (Please tick the appropriate columns)

Warm-up		Stretching	
Diving		Tumble turns	
Kicking		Pulling	
Butterfly		Drills	
Backstroke		Paddles	
Breaststroke		Fin work	
Freestyle		Parachutes	
Stretch cords		Bands	
Weight belts		Snorkel	
Other (please specify)			

Section 4: Present Swimming Injuries

47. Are you **presently** suffering with any injuries due to swimming?

Yes	No

(If you answered No please moved to question 57)

48. If you answered yes to Q47 please specify your current injuries. (Maximum of 3 injuries in **order of severity**)

	Present Injuries
1.	
2.	
3.	

Questions 49 – 57 are referring to you most severe swimming injury from the above- mentioned list.

49. Have you received treatment for the above-mentioned swimming injury(s)?

Yes	No

50. If yes, what type of treatment did you receive? (You can tick more than one treatment)

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Natural therapy e.g.: Homoeopathy	
Rehabilitation		Sports massage	
No treatment		Other (please specify)	

51. How would you describe to pain on a scale of 0 to 10 (0 represents no pain and 10 represents severe pain.)

0	1	2	3	4	5	6	7	8	9	10

52. At this moment how does your **present injury** affect your swimming?

Prevents swimming	Severe limitation & pain	Some limitation	Some pain	No effect

Please specify what you **are able to do** if your swimming was limited.

.....

.....

53. How long have you been **suffering** with this injury?

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

54. What is the longest period this **present injury** has **prevented** you from swimming?

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

55. What do you feel is the most likely cause for your injury?

Insufficient warm-up		Over training	
Stretching		Insufficient rest	
Over racing		Poor nutrition	
Injured while racing		Poor Technique	
Other (please specify)			

56. During which activity was your present injury sustained?

Warm-up		Stretching	
Diving		Tumble turns	
Kicking		Pulling	
Butterfly		Drills	
Backstroke		Paddles	
Breaststroke		Fin work	
Freestyle		Parachutes	
Stretch cords		Bands	
Weight belts		Snorkel	
Other (please specify)			

57. During what part of your swimming cycle were you injured?

Beginning of a cycle	Mid-cycle	Hell week	Taper

APPENDIX H

LETTER OF INFORMATION (Pilot Study)

Dear Participant,

Welcome to my study. Thank you for your interest.

The title of my research project is: A Profile of Musculoskeletal Injuries in Competitive swimmers in the greater Durban Area

Name of supervisor:	Dr. C. Korporaal (031-2042094) M.Tech: Chiropractic, CCSP, CCFC, ICSSD
Name of Research Student:	Kelly Sutherland (031-2042205 / 083 777 3632)
Name of Institution:	Durban University of Technology

The purpose of the study:
This study will involve research on competitive swimmers in the greater Durban area to determine the factors influencing the occurrence of swimming injuries in Kwazulu-Natal.

Procedures:
You will be required to complete a questionnaire about swimming injuries, where and how they occur. The average time for swimmer to complete the questionnaire will be 15 – 30 minutes.

Benefits:
Should you be suffering from any injuries during the course of your participation in this research, you are offered 1 optional free Chiropractic treatment at the Chiropractic Day Clinic at the Durban University of Technology. Also the results of this research will be forwarded to the Swimming clubs for distribution to your coach, to allow for improved recommendations with regard to your training. This will assist in the general improvement of the state of swimming in this province.

Risks/ Discomforts and Cost:
There are no risk / discomfort or cost involved from your participation in the study.

Confidentiality:
All patient information is confidential and the results will be used for research purposes only. You have the right to be informed of any new findings that are made and you may ask questions of an independent source if you so wish. If you are not satisfied with any area of the study please feel free to contact the Durban University of Technology Research Ethics Committee.

Thank you for your participation,
Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)

Dr. C. Korporaal
(Supervisor)

APPENDIX I

LETTER OF CONSENT / ASSENT (Pilot Study)

Dear Participant,

I am conducting research on musculoskeletal Injuries among swimmers in the greater Durban area. The purpose of this study is to investigate the frequency and nature of injuries among swimmers and to help identify potential risk factors.

This study will include swimmers, from swimming clubs in the Durban area. If you agree to participate, you will be required to complete a questionnaire. All the information supplied by you will be treated confidentially and used for research purposes only.

Participation is voluntary and failure to participate will not result in any adverse consequences.

Please feel free to contact Kelly Sutherland (researcher), or my supervisor, Dr. Charmaine Korporaal if you have any questions.

Thank you very much
Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)
031 204 2205 (w) 083 777 3632(c)

Dr. C. Korporaal
(Supervisor)
031 204 2533 (w)

I _____ hereby agree to Participate in the above-mentioned study.

Signature: _____ Date: _____

Parent's Name _____

Signature: _____ Date: _____

APPENDIX J

CONSENT / ASSENT FORM (Pilot Study)

Date:

Title of research project: A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area.

Name of supervisor: Dr. C. Korporaal (031-2042094)
M.Tech: Chiropractic, CCSP, CCFC, ICSSD

Name of Research Student: Kelly Sutherland
(031-2042205/ 083 777 3632)

Name of Institution: Durban University of Technology

Please circle the appropriate answer

1. Have you read the patient information sheet? YES/NO
2. Have you had opportunity to ask questions regarding this study? YES/NO
3. Have you received satisfactory answers to your questions? YES/NO
4. Have you had an opportunity to discuss this study? YES/NO
5. Have you received enough information about this study? YES/NO
6. Who have you spoken to regarding this study?
   _____
7. Do you understand the implications of your involvement in this study? YES/NO
8. Do you understand that you are free to withdraw from this study? YES/NO

a) At any time?
b) Without having to give a reason for withdrawing?
c) Without affecting your future health care?

9. Do you agree to voluntarily participate in this study? YES/NO

IF YOU HAVE ANSWERED NO TO ANY OF THE ABOVE, PLEASE OBTAIN THE NECESSARY INFORMATION FROM THE RESEARCHER AND / OR SUPERVISOR BEFORE SIGNING. THANK YOU.

PLEASE PRINT IN BLOCK LETTERS

Patients Name _____ Signature_____

Witness' Name _____Signature_____

Researchers' Name _____ Signature_____

Guardian's/
Parent's Name_____ Signature_____

Appendix K
Pilot Study Questionnaire Evalution Sheet

1 What is your opinion of the subject presented in this questionnaire?
(Please tick the most appropriate box)
- 1.1 Extremely interesting ☐
- 1.2 Interesting ☐
- 1.3 Average ☐
- 1.4 Boring ☐
- 1.5 Very boring ☐

2 Do you think the topics raised in this questionnaire were adequately covered?
- 2.1 Yes ☐
- 2.2 No ☐

3 What is your opinion about the Letter of Information?
(Please tick one box only)
- 3.1 Very clear ☐
- 3.2 Clear ☐
- 3.3 Adequate ☐
- 3.4 Unclear ☐
- 3.5 Needs revising ☐

4 How would you describe the instructions accompanying each of the questions?
(Please tick one box only)
- 4.1 Very clear ☐
- 4.2 Clear ☐
- 4.3 Adequate ☐
- 4.4 Unclear ☐
- 4.5 Needs revising ☐

5 Do you think the questionnaire is too long?
- 5.1 Yes ☐
- 5.2 No ☐

6 What is your opinion of the wording of the questionnaire?
(Please tick the appropriate box)
- 6.1 The meaning of **all questions** is absolutely clear ☐
- 6.2 The meaning of **most** questions is clear ☐
- 6.3 There is too much chiropractic/ medical jargon ☐
- 6.4 The questions will not be understood by lay persons ☐
- 6.5 The questionnaire needs to be revised because it is unclear ☐

If you had any difficulty answering any question/s, please write the number/s of the question/s in the space below with a suggestion on how the question/s can be improved?

_____

_____

_____

_____

Thank you for your most valuable time in helping me with my research project.
Please be reminded that the topics discussed above are strictly confidential.

APPENDIX L

Questionnaire no....

Durban University of Technology: Department of Chiropractic

A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area

Competitive Swimmers injury Questionnaire

Section 1: Patient Information

1. Age in years? Years

2. What is your gender? Male | Female

3. Which ethnic group do you belong to?

Black	White	Coloured	Asian	Indian	Other (please specify)

4a. Do you do any other **exercise** (e.g. weight training/ gym/ spinning) on a regular basis (i.e. twice a week.) besides swimming?

Yes | No

4b. If yes please specify.

.....

.....

5a. Have you ever sustained an injury due to the above mentioned exercise? (If no move to question 6)

Yes | No

5b. Please state your worst **two injuries** from the exercises mentioned in question 4b.

.....

.....

6. Has the injury/s mentioned in question 4 prevented you from swimming for any period of time?

Yes | No

7a. Do you **compete** in any other **sport** (e.g. waterpolo, hockey, cricket, etc.) besides swimming?

Yes | No

7b. If yes please specify.

.....

.....

8. Please state your worst two injuries from the **sport(s)** mentioned in question 7b.

.....

.....

9. Has the sports injury/s mentioned in question 7 prevented you from swimming for any period of time? | Yes | No |

10. In your opinion do you eat a balanced diet? | Yes | No |

11. Do you take any supplements on a regular basis? | Yes | No |

	Tick
Protein Shake	
Multivitamins (please specify)	
Creatine	
Vitamin B injections	
Other (please specify)	

12. If you answered yes to question 11, please specify what supplements you are taking.

13a. To your knowledge are there any hereditary diseases in your family (e.g. Arthritis, Scoliosis, musculoskeletal diseases)? Which may affect your swimming at a competitive level. | Yes | No |

13b. If Yes please specify the disease(s)

.....

.....

Section 2: Swimming History

14. At what age did you start swimming competitively? | Years |

15. How many years have you been swimming competitively? | Years |

16. On average how many hours per week do you train swimming? | Hours |

17. What is the average duration of each swimming session? | Hours |

18. On average how many kilometres do you swim per week? | Kilometres |

19. On average how many sessions per week do you swim? | Sessions |

20. What is the average time (rest) between swimming sessions? Hours

21. On average how many hours per week of land training (gym) do you do?

Hours

22. On average how many hours per day do you spend stretching?

Hours

23. When do you usually stretch?

Before training	After training	Before and After training	Never

24. What is your main stroke? (Only tick one)

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

25. What is your second main stroke? (Only tick one)

Butterfly	Backstroke	Breaststroke	Freestyle	Individual Medley

26. Would you classify yourself as? (Can tick more than one)?

Sprinter (50 /100m)	Middle distance swimmer (200 /400m)	Long distance swimmer (800 / 1500m)	Open water swimmer (1km +)

27. What are your 2 main events do you compete in? (Include distance and stroke)

.....

.....

28. What are your 2 secondary events do you compete in? (Include distance and stroke)

.....

.....

29. What other events do you swim? (Include distance and stroke)

.....

.....

30. To which side do you breathe?

Left	Right	Bilateral

31. What is the highest level at which you have competed?

Schools	Provincial	National	International	Other

If other, please specify.

.....

.....

.....

32. On average how many galas do you swim in a season? | Galas per season |

33. On average how many races do you swim per gala? | races |

34a. Do you receive any maintenance treatment (for injury prevention) on a regular basis?

Yes	No

34b. If yes, please specify by ticking appropriate treatments below

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Homoeopathy	
Rehabilitation		Sports massage	
No treatment		Other (please specify)	

35. Do you receive regular **stroke correction**-at least once per month?

Yes	No

36. What equipment do you use on a regular basis while swimming training?

Kick board		Bands	
Pull buoy		Fins	
Weight belts		Parachutes	
Stretch cords		Paddles	
Snorkel			
Other (please specify)			

Section 3: Previous Swimming Injuries

37. Have you **ever** sustained an injury due to swimming? (If No please move to question 47)

Yes	No

38. If yes, name the injury? (Was it traumatic, a sudden injury or did it occur over a long period of time?) (tick the appropriate box/s)

	Name Injury	Traumatic or accident?	Sudden onset?	Over a period time?
1				
2				
3				
4				
5				

39. Have you **ever** received treatment for your swimming injury?

Yes	No

40. If yes, what type of treatment did you receive? (You can tick more than one treatment)

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Natural therapy e.g.: Homoeopathy	
Rehabilitation		Sports massage	
Other (please specify)			

41a .How often have the following areas of your body been injured while swimming? (This includes any injuries from swimming sustained at **any time during your swimming career.)**

(Please tick the appropriate columns)

	Area of body	**Seldom (once or twice)**	**Often (3-5 times)**	**Very often (more than 5 times)**
1.	A. Foot/ toes			
2.	B. Ankle			
3.	C. Achilles tendon			
4.	D. Leg (calf/ Shin)			
5.	E. Knee			
6.	F. Hamstring (back of leg)			
7.	G. Quadriceps (front of leg)			
8.	H. Hip / Groin			
9.	I. Lower Back			
10.	J. Upper Back			
11.	K. Neck			
12.	L. head			
13.	M. Shoulder			
14.	N. Biceps (front of upper arm)			
15.	O. Triceps (back of upper arm)			
16.	P. Elbow			
17.	Q. Forearm			
18.	R. Wrist			
19.	S. Hand			
20.	T. Other (please specify)			

41b. From the list above (Q.41 1-20) please state the area(s) that sustained the worst injured:

.....

.....

42. Consider the worst injury that you have sustained during swimming. How would you describe it? (Please tick the appropriate columns)

Mild	Moderate	Severe

43. How have the injuries listed below affected your swimming? (Please tick appropriate column and if they **limited your swimming** please will you **specify what you were able to do?** e.g. kicking)

	Area of body	**Prevented swimming**	**Limited swimming (specify)**	**No effect**
1.	Foot/ toes			
2.	Ankle			
3.	Achilles tendon			
4.	Leg (calf/ Shin)			
5.	Knee			
6.	Hamstring (back of leg)			
7.	Quadriceps (front of leg)			
8.	Hip / Groin			
9.	Lower Back			
10.	Upper Back			
11.	Neck			
12.	Head			
13.	Shoulder			
14.	Biceps (front of upper arm)			
15.	Triceps (back of upper arm)			
16.	Elbow			
17.	Forearm			
18.	Wrist			
19.	Hand			
20.	Other (please specify)			

44. What is the **longest period**, which you were **unable** to swim due to any the above-mentioned injury/s? (Please tick the appropriate columns)

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

45. What do you feel is the most likely cause for your injury? (Please tick the appropriate columns)

Insufficient warm-up		Over training	
Stretching		Insufficient rest	
Over racing		Poor nutrition	
Injured while racing		Poor Technique	
Other (please specify)			

46. During which activity was your injury sustained? (Please tick the appropriate columns)

Warm-up		Stretching	
Diving		Tumble turns	
Kicking		Pulling	
Butterfly		Drills	
Backstroke		Paddles	
Breaststroke		Fin work	
Freestyle		Parachutes	
Stretch cords		Bands	
Weight belts		Snorkel	
Other (please specify)			

Section 4: Present Swimming Injuries

47. Are you **presently** suffering with any injuries due to swimming?
(If you answered No please moved to question 57)

Yes	No

48. If you answered yes to Q47 please specify your current injuries.
(Maximum of 3 injuries in **order of severity**)

	Present Injuries
1.	
2.	
3.	

Questions 49 – 57 are referring to you most severe swimming injury from the above- mentioned list.

49. Have you received treatment for the above-mentioned swimming injury(s)?

Yes	No

50. If yes, what type of treatment did you receive?
(You can tick more than one treatment)

Bracing / strapping		Medication/ injections	
Orthopaedic / surgery		Home remedies e.g.: ice	
Physiotherapy		Nutritional therapy	
Chiropractic		Natural therapy e.g.: Homoeopathy	
Rehabilitation		Sports massage	
No treatment		Other (please specify)	

51. How would you describe to pain on a scale of 0 to 10 (0 represents no pain and 10 represents severe pain.)

0	1	2	3	4	5	6	7	8	9	10

52. At this moment how does your **present injury** affect your swimming?

Prevents swimming	Severe limitation & pain	Some limitation	Some pain	No effect

Please specify what you **are able to do** if your swimming was limited.

.....

.....

53. How long have you been **suffering** with this injury?

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

54. What is the longest period this **present injury** has **prevented** you from swimming?

Less than 1 month	Less than 3 months	3-6 months	Greater than 6 months

55. What do you feel is the most likely cause for your injury?

Insufficient warm-up		Over training	
Stretching		Insufficient rest	
Over racing		Poor nutrition	
Injured while racing		Poor Technique	
Other (please specify)			

56. During which activity was your present injury sustained?

Warm-up		Stretching	
Diving		Tumble turns	
Kicking		Pulling	
Butterfly		Drills	
Backstroke		Paddles	
Breaststroke		Fin work	
Freestyle		Parachutes	
Stretch cords		Bands	
Weight belts		Snorkel	
Other (please specify)			

57. During what part of your swimming cycle were you injured?

Beginning of a cycle	Mid-cycle	Hell week	Taper

APPENDIX M

LETTER OF INFORMATION

Dear Participant,

Welcome to my study. Thank you for your interest.

The title of my research project is: A Profile of Musculoskeletal Injuries in Competitive swimmers in the greater Durban Area

Name of supervisor: Dr. C. Korporaal (031-2042094)
M.Tech: Chiropractic, CCSP, CCFC, ICSSD

Name of Research Student: Kelly Sutherland
(031-2042205 / 083 777 3632)

Name of Institution: Durban University of Technology

The purpose of the study:
This study will involve research on competitive swimmers in the greater Durban area to determine the factors influencing the occurrence of swimming injuries in Kwazulu-Natal.

Procedures:
You will be required to complete a questionnaire about swimming injuries, where and how they occur. The average time for swimmer to complete the questionnaire will be 15 – 30 minutes.

Benefits:
Should you be suffering from any injuries during the course of your participation in this research, you are offered 1 optional free Chiropractic treatment at the Chiropractic Day Clinic at the Durban University of Technology. Also the results of this research will be forwarded to the Swimming clubs for distribution to your coach, to allow for improved recommendations with regard to your training. This will assist in the general improvement of the state of swimming in this province.

Risks/ Discomforts and Cost:
There are no risk / discomfort or cost involved from your participation in the study.

Confidentiality:
All patient information is confidential and the results will be used for research purposes only. You have the right to be informed of any new findings that are made and you may ask questions of an independent source if you so wish. If you are not satisfied with any area of the study please feel free to contact the Durban University of Technology Research Ethics Committee.

Thank you for your participation,
Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)

Dr. C. Korporaal
(Supervisor)

APPENDIX N

LETTER OF CONSENT / ASSENT

Dear Participant,

I am conducting research on Musculoskeletal Injuries among Swimmers in the greater Durban area. The purpose of this study is to investigate the frequency and nature of injuries among swimmers and to help identify potential risk factors.

This study will include swimmers, from swimming clubs in the Durban area. If you agree to participate, you will be required to complete a questionnaire. All the information supplied by you will be treated confidentially and used for research purposes only.

Participation is voluntary and failure to participate will not result in any adverse consequences.

Please feel free to contact Kelly Sutherland (researcher), or my supervisor, Dr. Charmaine Korporaal if you have any questions.

Thank you very much
Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)
031 204 2205 (w) 083 777 3632(c)

Dr. C. Korporaal
(Supervisor)
031 204 2533 (w)

I _____ hereby agree to Participate in the above-mentioned study.

Signature: _____ Date: _____

Parent's Name _____

Signature: _____ Date: _____

APPENDIX O

CONSENT / ASSENT FORM

Date:

Title of research project: A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area.

Name of supervisor:	Dr. C. Korporaal (031-2042094) M.Tech: Chiropractic, CCSP, CCFC, ICSSD
Name of Research Student:	Kelly Sutherland (031-2042205/ 083 777 3632)
Name of Institution:	Durban University of Technology

Please circle the appropriate answer

1. Have you read the patient information sheet? YES/NO
2. Have you had opportunity to ask questions regarding this study? YES/NO
3. Have you received satisfactory answers to your questions? YES/NO
4. Have you had an opportunity to discuss this study? YES/NO
5. Have you received enough information about this study? YES/NO
6. Who have you spoken to regarding this study?

   _____
7. Do you understand the implications of your involvement in this study? YES/NO
8. Do you understand that you are free to withdraw from this study? YES/NO

a) At any time?
b) Without having to give a reason for withdrawing?
c) Without affecting your future health care?

9. Do you agree to voluntarily participate in this study? YES/NO

IF YOU HAVE ANSWERED NO TO ANY OF THE ABOVE, PLEASE OBTAIN THE NECESSARY INFORMATION FROM THE RESEARCHER AND / OR SUPERVISOR BEFORE SIGNING. THANK YOU.

PLEASE PRINT IN BLOCK LETTERS

Patients Name _____ Signature_____

Witness' Name _____Signature_____

Researchers' Name _____ Signature_____

Guardian's/
Parent's Name_____ Signature_____

APPENDIX P

LETTER OF PERMISSION

Dear Coach,

This letter serves as a request to perform research at your swimming club.

The title of my research project is: A profile of Musculoskeletal Injuries in Competitive Swimmers in the greater Durban Area.

Name of supervisor:	Dr. C. Korporaal (031-2042094) M.Tech: Chiropractic, CCSP, CCFC, ICSSD
Name of Research Student:	Kelly Sutherland (031-2042205 / 083 777 3632)
Name of Institution:	Durban University of Technology

The purpose of the study:

This study will involve research on competitive swimmers in the greater Durban area to determine the factors influencing the occurrence of swimming injuries in Kwazulu-Natal.

Procedures:

The swimmers will be required to complete a questionnaire about swimming injuries, where and how they occur. The average time for swimmer to complete the questionnaire will be 15 – 30 minutes.

Benefits:

Should they be suffering from any injuries during the course of their participation in this research, they are offered 1 optional free treatment at the Chiropractic Day Clinic at the Durban University of Technology. Also the results of this research will be forwarded to you as the Club leader of your swimming club to allow for improved recommendations with regard to training.

Risks/ Discomforts and Cost:

There are no risk / discomfort or cost involved from your participation in the study.

Confidentiality:

All patient information is confidential and the results will be used for research purposes only. You have the right to be informed of any new findings that are made and you may ask questions of an independent source if you so wish. If you are not satisfied with any area of the study please feel free to contact the Durban University of Technology Research Ethics Committee. If there are any questions please do not hesitate to contact myself, Kelly Sutherland, or my supervisor, Dr Korporaal on the above-mentioned numbers.

Yours sincerely,

Kelly Sutherland
(Chiropractic Intern)

Dr. C. Korporaal
(Supervisor)

I (name) _____ hereby give Kelly Sutherland consent to conduct the above-mentioned research at this Swimming club.

Signature: _____ Date: _____

APPENDIX Q

LETTER OF PERMISSION

To Whom It May Concern:

My name is Kelly Sutherland; I am currently doing my Masters Degree in Chiropractic's at the Durban University of Technology,
The title of my research project is: A profile of Musculoskeletal Injuries in Competitive Swimmers in the greater Durban Area.

Name of supervisor:	Dr. C. Korporaal (031-2042094) M.Tech: Chiropractic, CCSP, CCFC, ICSSD
Name of Research Student:	Kelly Sutherland (031-2042205 / 083 777 3632) (Fax: 031 2012605 / 031 5024727)
Name of Institution:	Durban University of Technology

The purpose of the study:
This study will involve research on competitive swimmers in the greater Durban area to determine the factors influencing the occurrence of swimming injuries in Kwazulu-Natal.

Procedures:
The swimmers will be required to complete a questionnaire about swimming injuries, where and how they occur. The average time for swimmer to complete the questionnaire will be 15 – 30 minutes.

Benefits:
Should they be suffering from any injuries during the course of their participation in this research, they are offered 1 optional free treatment at the Chiropractic Day Clinic at the Durban University of Technology. Also the results of this research will be forwarded to you as the Club leader of your swimming club to allow for improved recommendations with regard to training.

Cost:
There is no cost involved from your participation in the study.

Based on the above-mentioned study, I am required to seek permission at those venues where swimming clubs are housed e.g.: King's Park. Therefore I would like to request tour permission to utilize any municipal venue that houses a swimming club within the confines of the greater Durban Area.

Yours in anticipation,

Kelly Sutherland
(Chiropractic Intern)

Dr. C. Korporaal
(Supervisor)

I (name) _____ hereby give Kelly Sutherland consent to conduct the above-mentioned research at any Municipal venue housing a swimming club.
Signature: _____ Date: _____

ARTICLE

FOR

REVIEW

A Profile of Musculoskeletal Injuries in Competitive Swimmers in the Greater Durban Area.

Kelly M. Sutherland[1]
M.Tech Chiropractic (SA)

Dr. C. Korporaal[2]
M.Tech: Chiropractic (SA) CCFC (SA), CCSP (USA), ICSSD (USA)

1. Dept Chiropractic, D.U.T., P.O. Box 1334, Durban 4001
2. Dept Chiropractic, D.U.T., P.O. Box 1334, Durban 4001

All correspondence addressed to: Dr. C. Korporaal; Tel: + 27 (0) 31-373 2611; Fax: + 27 (0) 31-202 3632; E-mail: charmak@dut.ac.za; Durban University of Technology; P.O. Box 1334, Durban, 4001, South Africa (RSA).

Abstract

Introduction:

Swimming is one of the most popular participation sports [1] as people are drawn to swimming for leisure, cardiovascular workouts, or competition [2] .As a result the sport of swimming has improved greatly over the past 20 years [3] .

Objectives:

The aim of this study was to determine a profile of musculoskeletal injuries in competitive swimmers in the greater Durban area of KwaZulu-Natal, South Africa; to determine whether there are any relationships that exist between risk factors identified in other studies and swimming injuries sustained in this study, and to compare the results with those of other international data that is available.

Therefore; for the purpose of this study, the following information was gathered in order to build up an injury profile:

- Demographics of Competitive Swimmers in South Africa,
- The participants swimming history,
- The presence of any past or current injuries and
- Factors associated with current and previous injuries were also investigated.

Methods:

This study was a prospective, cross-sectional, questionnaire based study, investigating the profile of musculoskeletal injuries in 101 competitive swimmers in the greater Durban area.

The data was collected by means of a self-administrated questionnaire, which was completed by the participants, under the supervision of the researcher / parents / coach.

The study was limited to competitive swimmers residing in the Greater Durban Area. Participants were required to be between 10 and 30 years of age, and compete in a minimum of either 3 minor galas, 1 National gala, 1 International event or a combination of the above in the season during which this research was conducted.

Results:

The overall prevalence of ever sustaining an injury due to swimming was relatively high (53.5%). The shoulder was the site where injury was most likely to occur. The factors associated with injury were previous injury due to another form of exercise or sport, duration and number of sessions swum per week.

All other associations analysed resulted in inconclusive findings and warrant further investigation with due consideration to the recommendations from this study.

Keywords: swimming; injuries; quantitative profile

Introduction:

Swimming is one of the most popular participation sports [1] as people are drawn to swimming for leisure, cardiovascular workouts, or competition [2]. As a result the sport of swimming has improved greatly over the past 20 years [3].

When assessing the profile of musculoskeletal injuries in competitive swimmers there are a number of parameters that must be considered. In a study by Rover and Nichols[4], it was found that a significant relationship between knee pain and the increase in swimmers age, number of years of competitive swimming, an increase in breaststroke training distance and a decrease in warm-up distance existed. According to a study by McMaster and Troup [5], regarding the prevalence of shoulder pain in competitive swimmers, they found a relationship existed between the shoulder pain and weight training, the use of hand paddles, the use of a kickboard, stretching and a variety of resistance activities play a role in aggravating the shoulder pain. Thus a swimmers stroke and a correct technique seem to play a role in vital role in injury prevention [6].

In this regard much research has been completed in the individual stroke phases as well as individual injuries[5, 7] associated with the stroke phases but no profile of these injuries exists for the South African swimming population.

This research aims to develop a profile of musculoskeletal injuries in Competitive Swimmers in the Greater Durban area, in order to create a starting point for the understanding the injuries present and thus be able to address factors that may predispose to injuries in competitive swimmers.

The Competitive Swimmers Injury Questionnaire (CSIQ) was developed by the researcher and validated by a focus group and pilot study. The CSIQ was a self-administered questionnaire distributed to the total number of swimmers registered with the KwaZulu-Natal Aquatics Association[10] in the greater Durban area, totaling 400 swimmers. Along with the CSIQ was a letter of

Information, and an Informed Consent/ Assent form. The questionnaires were returned to the researcher or their swimming coach, where they were collected and stored.

Data was analysed with SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). A p value of <0.05 was considered as statistically significant.

Method:

Design:

This study was a prospective, cross-sectional, questionnaire- based study, investigating the profile of musculoskeletal injuries in competitive swimmers in the greater Durban area.

The data was collected by means of a self-administrated[11] questionnaire, which was completed by the participants, under the supervision of the researcher / parents / coach.

This design was approved by the Durban University of Technology, Faculty of Health Sciences Research Committee and the Ethics Review Board. This approval declared that the research conformed to the standards set by the Helsinki Declaration of 1975.

Sample:

A total sample method was used [12] as the entire population was invited to participate in the study. Sample stratification by region or any other variable was not considered for this study in order to negate the effects of stratification on injury point prevalence and incidence [13].

The entire population of competitive swimmers registered with KZN Aquatics Associations [10] was invited to participate in the study. Thus the sample size

was Four hundred (400) swimmers between the ages of 10 and 30 years of age [10].

The response rate required prior to statistical analysis was defined as a minimum response rate of 25%, thus one hundred (100) competitive swimmers was required to make this study's statistics generalisable to the population under study[10]. In a similar study on gymnasts by Adamson[14], a minimum response rate of 16% was required, which still yielded statistically valid data.

Criteria for Participation in the Study

Permission was attained to conduct the research process, from the Municipality or owner of the swimming pools, prior to the commencing the study. Coaches of each of the swimming clubs in the greater Durban area were contacted, either in person or telephonically and permission was obtained to conducted research at their respective clubs. The Letter of Permission was signed prior to the swimmers having been spoken to. Each participant was required to read a letter of information and sign an informed consent or an assent form (with the parents signing the consent form). By signing the consent / assent forms the participant acknowledged the terms and conditions of the research process.

Inclusion criteria:

Participants had to be Competitive swimmers between the ages of 10 and 30 years of age, residing in the KwaZulu Natal province, principally in the Greater Durban area. Participants were required to fill in the Informed Consent/ Assent form and a letter of Consent/ Assent, therefore providing an informed decision to participate in the study. Parental consent was obtained for participants under the age of 18 years [15].The participant had to be at least second language English speaking. As the instructions were issued in English, and concurrent validity of the questionnaire has not been completed in another language.

Exclusion criteria:

Participants who did not correctly complete and sign the Informed Consent / Assent form and the Letter of Consent / Assent and if parental consent / assent was not obtained for participants under the age of 18 years, they were excluded from the study.

Data Collection Procedure:

Permission was received from the Municipality or the owner of the swimming pools, the swimming coaches were contacted to inform them of the study and to obtain permission to carry out the research at their swimming clubs.

Once permission was received from the swimming coaches, the researcher approached all the swimmers at the relevant swimming clubs, and informed them of the study.

Participants meeting the inclusion criteria for the study received a letter of Information, an Informed Consent/ Assent Form and a Letter of Consent/ assent to complete along with the CSIQ to complete.

The questionnaires were administrated in a semi-supervised manner, in a group environment. The participants all received the same instructions and questions or queries were handled in a similar manner.

Participants filled out the questionnaire with respect to:

- Demographics of the swimmers in the Greater Durban area.
- The participants' swimming history
- Information on the participants' participation in other sports and injuries attained during these activities.
- The presence of any current or lifetime injuries, and
- The factors relating to these injuries were investigated.

The data was then statistically analysed and interpreted to determine the musculoskeletal injury profile of competitive swimmers in the Greater Durban area, of KwaZulu-Natal, South Africa.

Questionnaire development:

The questionnaire was developed using an existing questionnaire designed by Adamson[14] for gymnasts. For which permission was obtained prior to commencing the study. Parameters found in the literature were also used to aid in the development of the CSIQ. A number of parameters included in the CSIQ were as a result of the Focus Group.

The CSIQ was then validated, by means of a focus group and a pilot study. These processes where used to confer validity, where validity refers to establishing the accuracy and trustworthiness of an instrument, data and findings in the research thereby ensuring that future research utilizing that particular tool is accurate[16] .

The questionnaire was amended as a result of the critical input of the focus group participants. Piloting the questionnaire followed, according to Fink and Kosecoff [17] leading to the finalisation of the CSIQ to be used in the data collection process.

The Final questionnaire was a fully quantitative, containing 57 questions. The CSIQ was divided into four sections the Patient Demographics, Patients Swimming History, Previous swimming injuries and Present swimming injuries.

Section one the Patient Demographics included questions pertaining to the swimmers age, gender, and ethnic group, involvement in other exercise or sporting activities and any injuries pertaining to these activities. Dietary and the use of supplementation are also included in this section, as well as questions pertaining to a family history of musculoskeletal diseases.

Section two the Patients Swimming History included questions pertaining to the swimmers involvement in the sport of swimming. The age at which the started swimming competitively, the number of years the have swam competitively. It also included questions regarding there training schedule i.e. the number of hours they swim per week, the number of session the attend per week, the duration of each swimming session, the distance the swim per week, the amount of rest they have between each swimming session. The patients swimming history also refers to the swimmers classification, questions pertaining to the level of competition at which they compete and information regarding there participants in galas. This section also looked at the swimmers dry land training, there stretching habits, the equipment the use during swimming training and weather the receive stroke correction.

Section three and four the patients Previous Swimming injuries and Present Swimming injuries. These two sections included questions pertaining to the swimmers past and present injuries as well as the treatment that they may have received for there injury.

Frequency of administration of the Questionnaire:

The CSIQ was administered once per participant.[12]

Statistical Methods:

Data was analysed with SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). A p value of <0.05 was considered as statistically significant.

Descriptive analysis for categorical variables was by means of frequency tables and bar charts, and for quantitative variables summary statistics were generated such as mean, standard deviation and range.

Hypothesis testing was used to assess associations between risk factors and ever having a swimming injury. Quantitative variables were compared using t-

tests and categorical variables were compared using Pearson's chi square tests or Fisher's exact tests as appropriate (Bivariate analysis). In order to determine the independent risk factors associated with injury, logistic regression analysis was used (multivariate analysis). All risk factors significantly associated with injury on bivariate analysis were entered into the model and a backwards elimination technique was used using likelihood ratios to arrive at a final model.

An attempt was made to identify potential risk factors seen in pervious studies, existed in the participants in this study. If so, whether there were any significant relationships that existed between the risk factors and the swimming injuries present in this study. The results from the questionnaire were compared to available international data.

Results:

There was a similar number of male (49.5%) and female (50.5%) participants in this study ranging between the ages of 10 and 30 years, with a mean age of 16.7 years. The sample population appeared to be predominately white (89.1%). The most popular main stroke was Freestyle (38.6%), followed by Butterfly (21.8%). The majority of swimmers classified themselves as being Sprinters (78.2%). Fifty eight percent (58.4%) of participants received regular stroke correction. Regular maintenance treatment was received by 18 participants, with sports massages (9.9%) being the common treatment, followed by Chiropractic (5.94%).

The participants mean age at which they started swimming was 9.6 years of age. The number of years of swimming competitively was between 1 and 20 years, with a mean number of 6.7 years of competitive swimming. The swimmers trained between 2.5 and 85km per week in between 2 and 11, 1.8 hour swimming training sessions, with a mean rest time of 19.6 hours between each swimming session.

Seventy nine percent (79.2%) of participants in this study did another form of exercise besides swimming, this mainly involved gym (34.6%), Pilates, weight training and running. Of these participants 35.4% had been injured in the past due to the exercise, 66.7% were prevented from swimming due to the injury. A large number of participants (69.3%) competed in another sport besides swimming, 53,6% of these participants had been injured as a result of this sport and 83.3% were prevented from swimming due to the injury.

Fifty four percent (53.5%) of competitive swimmers had a lifetime prevalence of swimming injuries. The shoulder was the most commonly injured site (n=38, 70.4% of those who had ever injured themselves from swimming). The onset of the lifetime injuries were mainly over a period of time. Of those whom had ever been injured 86.8% had received treatment, with Physiotherapy (64.2%) being the most common type of treatment received.

The prevalence of current swimming injuries was 17.8% (n=18). The majority of swimmers injured their shoulder (61.1%). The lower back was the second most commonly injured site with 16.67%of the injuries. The knee and the wrist were reported in 11.1% of the case each. The majority of currently injured swimmers received treatment (77.8%), with Physiotherapy being the most common type of treatment received (50%).

Participants blamed over training as the main cause for lifetime injuries (33.3%) followed by stretching in 31.5% and insufficient warm up in 25.9% of cases. Poor technique (22.2%) was also identified as a perceived cause form injury. "Other" cause accounted for 22.2% of injuries; theses included the lack of stretching, an intense training regime as well as hereditary and medical conditions. Freestyle and Butterfly were the activities during which the most injuries were sustained (38.9% and 35.2% respectively). Paddles were also identified as being associated with 33.3% of injuries. "Other" factors accounted for 16.7% of injuries; theses included gym or land training and being injured while racing.

Stretching was largely blamed for the current injuries, in 33.3% of the case. "Other" causes were also largely to blame in 33.3% of cases. "Other" causes included; insufficient or the lack of stretching, poor training techniques, muscle weakness, an intense training regime, the use of hand paddles, tumble turns and dives. Medical or hereditary conditions were also seen as an "other" cause for the current injuries. Over training was identified as a causative factor for their current injury in 27.8% of cases. Butterfly (38.9%) was identified as the activity during which the most current injuries were sustained, followed by the use of paddles (33.3%) and Freestyle (27.8%). "Other" causes included insufficient stretching and not knowing the cause of the current injury.

Statistically significant risk factors associated with injuries in competitive swimmers, are listed in Table 1. It was found that the number of swimming training session per week ($p=<0.001$) and the number of hours spent swimming per week ($p=<0.001$) as well as the rest between swimming sessions ($p=0.001$) were the most significant risk factors associated with swimming injuries.

Discussion:

Statistically significant findings included; the number of years training and the weekly training time[8].This may indicate that a longer period of training will increase the chance of sustaining a musculoskeletal injury. The longer you training may also be included as a possible risk factor for musculoskeletal pain in swimmers[8]. Musculoskeletal pain was present in swimmers with a longer history of training and who spent more time training. They found a significant statistical correlation ($p=<0.05$) between pain and age, number of years of training and weekly training time[8]. McMaster and Troup[5] found that the number of swimmer suffering with shoulder injuries increased with the skill level of the swimmer and presumably the number of years that had been participating in the sport[5].

Conclusion:

The overall prevalence of ever sustaining an injury due to swimming was relatively high (53.5%). The shoulder was the site where injury was most likely to occur. The factors associated with injury were previous injury due to another form of exercise or sport, duration and number of sessions swum per week.

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Tables

Table 1: Significant Statistical Findings

Rank	Significant Risk Factors Associated to Swimming Injuries	p value
1	No. of Training Sessions per week	p= <0.001
1	No. Hours Swum per week	p= < 0.001
2	Rest between each Session	P= 0.001
3	Injury of another Competitive Sport	p= 0.002
4	Age	p= 0.003
5	Duration of each Session	p= 0.004
6	Bands (Training Equipment used)	p= 0.007
7	No. Hour of Land Training	p= 0.013
8	Distance (km) Swum per week	p= 0.019
9	Injury from another form of Exercise	p= 0.025
10	No. years been Swimming Competitively	p= 0.030
11	Participation in other forms of Exercise	p= 0.038
12	Middle Distance Swimmer (Type of Swimmer)	p= 0.046

Table 2: Insignificant Statistical Findings

Rank	Insignificant Risk Factors Associated to Swimming Injuries	p value
1	Age at which Started Swimming	p= 0.961
2	Fins (Training Equipment used)	p= 0.878
3	Parachutes (Training Equipment used)	p= 0.861
4	Open Water Swimmer (Type of Swimmer)	p= 0.859
5	Paddles (Training Equipment used)	p= 0.824
6	Hereditary diseases	p= 0.810
7	Balanced Diet	p= 0.808
8	Pull Buoy (Training Equipment used)	p=0.729
9	Ethnic Group	p= 0.706
10	Stretch Cords (Training Equipment used)	p= 0.589
11	Main Stroke	p= 0.452
12	Snorkel (Training Equipment used)	p= 0.391
13	Long Distance Swimmer (Type of Swimmer)	p= 0.389
14	Gender	p= 0.366
15	Sprinter (Type of Swimmer)	p= 0.295
16	Kick Board (Training Equipment used)	p= 0.245
17	Weight Belt (Training Equipment used)	p= 0.205
18	Stretching	p= 0.123

Table 3: Borderline Statistical Findings

Rank	Borderline Risk Factors Associated to Swimming Injuries	p value
1	No. Hours spent Stretching	p= 0.053
2	Competing in other Sports	p= 0.056
3	Supplements	p= 0.077