Shoulder pain in Amateur fast bowlers: Incidence, associated factors and prevention

Muhammad Dawood

A thesis submitted to the Faculty of Health Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree Doctor of Philosophy.

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DECLARATION

I, Muhammad Dawood, declare that the work contained in this thesis is my own work, except to the extent indicated in the acknowledgements section.

This thesis is being submitted for the degree of Doctor of Philosophy, at the University of the Witwatersrand, Johannesburg, South Africa.

This work has not been submitted for any other degree or examination in this or any other university.

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ABSTRACT

Fast bowlers commonly suffer from shoulder pain and -injury. There is a dearth of information regarding the incidence of shoulder pain and its associated factors in amateur fast bowlers. Once the incidence of, and the factors associated to shoulder pain in fast bowlers are determined, shoulder pain could be addressed and prevented in this population.

The aim of this thesis was to develop, and determine the effectiveness of a shoulder-impairment exercise programme to address the biomechanical factors contributing to shoulder pain in amateur fast bowlers. The Northern Premier Cricket league is the highest form of club cricket (amateur cricket) in South Africa and was the source of the fast bowlers in this study. Three objectives were identified and the corresponding studies were executed chronologically. Firstly, a longitudinal cohort study was employed to determine the incidence of and associated factors to shoulder pain in fast bowlers whereby the amateur fast bowlers were tested for baseline values of shoulder muscle strength, stability, shoulder range of motion (ROM) and endurance. Information was provided by answering a baseline questionnaire regarding their anthropometrics, demographics, past injuries and playing roles. Throughout the 2018/2019 season they then answered a weekly questionnaire regarding their development of shoulder injury/pain. Secondly, a modified e-Delphi technique was employed to develop a shoulder exercise programme aimed at addressing these factors. Ten experts in the field of physiotherapy were sent the exercise programme and their comments and suggestions were applied accordingly. Thirdly, the effectiveness of the exercise program was tested via a quasi-experimental pre-post-test study design. One amateur cricket team was assessed before and after the completion of the exercise programme for a period of six weeks.

Nine (23%) of the fast bowlers sustained shoulder pain during the 2018/19 season. The associated factors to shoulder pain were (effect sizes): decreased internal rotation ROM (0.6); increased external rotation ROM (effect size=1.0); poor endurance (effect size= 0.5) and isometric muscle strength of selected muscles (0.3 - 0.5). The developed shoulder exercise programme addressing these factors had been found to: improve muscle strength

of the selected muscles (p=0.00-0.02), increase GHJ internal rotation (p=0.02), increase endurance and proprioception of the surrounding shoulder muscles: CKUEST (p=<0.001) and prone-Y and scaption testing positions (p=<0.001).
An exercise programme aimed at addressing the factors associated with shoulder pain was proven effective in addressing the biomechanical factors associated to shoulder pain. The ability of this programme to prevent shoulder pain in fast bowlers is recommended to be assessed in future studies.

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My father, you believed in me when no one else did, you raised me through the worst parts of my life. You taught me about hope and gave me the strength to keep on keeping on. You never saw the worst in me even when that was all to see. Everything I am is you.

I lost my best friend this year, my grandfather, he taught me that the true strength of a man is not in the weight he can lift, but in the way he carries his burdens. This PHD is dedicated to him. Without the lessons he taught me I would have never have been able to make it this far. It's been a long day without you old man, I will tell you all about it when I see you again.

I thank the Almighty for all he has blessed me with.

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DEFINITIONS OF TERMS USED IN THIS DOCUMENT

Term	Definition
All Rounder	A player that can specialize in both batting and bowling or a player that specializes in both batting and wicket keeping (Tallent, de Weymarn, Ahmun, & Jones, 2020)
Batter	A player on the batting side, or a player who specializes in batting (Lemmer, 2013)
Bowling/Bowler	The act of delivering the ball to the batter, a bowler is one who accomplishes this task (Lemmer, 2013).
Cricket	An open-air game played on a large grass field with ball, bats, and two wickets, between teams of eleven players, the object of the game being to score more runs than the opposition (Lemmer, 2013).
Dysfunction	Abnormal functioning of an anatomical structure (Mosby, 2009).
Fielding	A player on the fielding side, who tries to prevent the batter from scoring runs (Tallent et al., 2020).
Injury Incidence	Injury incidence considers the average number of squad members presenting with injury or illness for a given time period (Orchard, Ranson, et al., 2016).
Joint Congruency	The position when the joint surfaces fit the most perfectly into each other, and where the ligaments and joint capsule are maximally taut (Levangie & Norkin, 2011).
Premier League Cricket	For the current study, the term is used for players playing in the highest level club league – these are amateur cricketers who are not paid to play. This is the highest level of club cricket in South Africa. This league serves as a feeder to the professional cricket leagues and these cricketers play all formats of the game as well as are committed to activities of daily living.
Scapula Dyskinesis	Visible alterations in scapular position and motion patterns (McClure, Tate, Kareha, Irwin, & Zlupko, 2009).

ABBREVIATIONS USED IN THIS DOCUMENT

Abbreviation	Complete word
ABD	Abduction
ACT	Active
BS	Borg Scale
CKUEST	Closed Kinematic Upper Extremity Stability Test
D	Deltoid
ER	External Rotation
ER	External Rotation
FB	Fast Bowler
FL	Flexion
GHJ	Glenohumeral Joint
GIRD	Glenohumeral Internal Rotation Deficit
IR	Internal Rotation
IR	Internal Rotation
MR	Medial Rotation
NCU	Northern Cricket Union
NO	Normalized Score
PASS	Passive
PCL	Premier Cricket League
PO	Power score
REDCap	The Research electronic data capture system
RC	Rotator Cuff
ROM	Range of Motion
S	Strength
SA	Serratus Anterior
SDT	Scapula Dyskinesia
SH	Shoulder
W	Weighted

PREFACE AND DESCRIPTION OF THESIS SECTIONS

Overhead athletes commonly suffer from shoulder pain and injury. Fast bowlers are no different. The nature of fast bowling predisposes cricket fast bowlers to shoulder pain and injury. Amateur fast bowlers playing at the highest level of amateur cricket usually do not have a medical team on staff. They commonly participate in other sports and physical activity and do not undergo preseason testing or exercise intervention aimed at prevention of pain or injury. Amateur fast bowlers, unlike elite fast bowlers, do not participate in injury surveillance systems. The incidence of shoulder pain is thus unknown in this population. An investigation into the incidence of shoulder pain and the biomechanical factors associated to injury could facilitate efforts to prevent and rehabilitate shoulder pain. The work described in the chapters in this thesis aimed to investigate the incidence of and associated factors to shoulder pain in amateur fast bowlers. An exercise programme designed and refined by means of literature review and an e-Delphi, respectively, is described as well.

An overview of each chapter contained in this thesis will follow here:

Chapter 1 introduces the current study as a whole. The research question, aims and objectives are described in this chapter. In doing this **Chapter 1** provides a reflection of the problem statement and identifies how the study will be accomplished. It explains how the proposed study will contribute to the field of physiotherapy in sport, specifically fast bowlers, by describing the significance of the study as a whole.

Chapter 2 describes the literature related to all three studies in this thesis. The gaps identified in the available research are highlighted in terms of shoulder pain and -injury incidence as well as the associated factors to shoulder pain and -injury in amateur fast bowlers. This is then followed by the literature available regarding exercises aimed at addressing the biomechanical factors associated to shoulder pain in overhead athletes.

Chapter 3 describes Study 1, a longitudinal cohort study, investigating the incidence of shoulder pain in amateur fast bowlers. A cohort of baseline tests are used to investigate the association of biomechanical factors to shoulder pain over the 2018/19 season of amateur cricket. The incidence of and the associated factors to shoulder pain is described.

Chapter 4 describes a modified e-Delphi study (Study 2) used to validate and refine an evidence based exercise programme.

Chapter 5 illustrates a quasi-experimental pre-post-test study design employed to test the effectiveness of the exercise programme (Study 3) described in **Chapter 4.** The effectiveness of the exercise programme aimed at addressing the biomechanical factors associated to shoulder pain in amateur fast bowlers is determined and described.

In **Chapter 6** the thesis is concluded in terms of the objectives achieved. The limitations in terms of each of the studies presented in this thesis are summarised followed by the recommendations for future studies in relation to each study in this thesis.

JOURNAL SUBMISSIONS EMANATING FROM THE WORK PRESENTED IN THIS THESIS.

Paper one (Study 1) was submitted to the Journal of Orthopaedic and Sports Physical Therapy. The paper is titled: The incidence of and the associated factors to shoulder pain in amateur fast bowlers.

Paper two (Study 2) will be submitted to the Physiotherapy Theory and Practice. The paper will be titled: An exercise programme for shoulder pain, a modified e-Delphi study.

Paper three (Study 3) will be submitted to the Journal of Orthopaedic and Sports Physical Therapy. The paper will be titled: The effectiveness of an exercise programme addressing the factors associated to shoulder pain in amateur fast bowlers, a pre-post-test study.

CONFERENCE PRESENTATIONS EMANATING FROM THE WORK PRESENTED IN THIS THESIS

Study 1 was presented as a poster presentation at the University of the Witwatersrand faculty of Health Sciences research day 2020 titled: The incidence of and the associated factors to shoulder pain in amateur fast bowlers.

DISSEMINATION OF THE RESULTS

The results and findings of Studies 1 to 3 will be presented to the cricketers who participated in the study. The Northern Cricket Union and Cricket South Africa authorities will also be invited to the presentation and the main findings will be made available to them.

CONTRIBUTIONS OF AUTHORS TO THE PROJECT

As part of the declaration of this thesis, I acknowledge the contributions by the various individuals to this work as detailed below:

Conceptualisation, visualisation including experimental design, data collection and analysis for all work were devised by myself in conjunction with my supervisors, Prof

Benita Olivier and Dr Maria Cochrane with expert opinion provided by Professor Tania Van Rooijen (Delphi) and Professor Elena Libhaber (Statistics).

Investigation for Study 1 and 3 including; data collection, photography, information summary and data cleaning by myself, Jolandi Jacobs and Charlene Engelbrecht (the two research assistants).

Data curation, formal administration and writing including the drafting of written work, including the literature review and manuscripts (first and final drafts) were my responsibility. All authors have reviewed the drafts before they were and will be submitted for publication.

DETAILS OF MAIN CONTRIBUTING AUTHORS TO THIS THESIS

Muhammad A Dawood[1, 2]

Benita Olivier[1]

Maria E Cochrane[2]

[1]Department of Physiotherapy, Faculty of Health Sciences, University of the Witwatersrand; Johannesburg, South Africa. Address: Khanya Building (West), Wits Parktown Education Campus, 27 St Andrew's Road, Parktown, Johannesburg, 2193.

[2]Department of Physiotherapy, Faculty of Health Sciences, Sefako Makgatho Health Sciences University; Pretoria, South Africa. Address: 1 Molotlegi Road, Ga-Rankuwa, Pretoria, 2024.

Corresponding author: Muhammad A Dawood. Address: 1 Molotlegi Road, Ga-Rankuwa, Pretoria 2024; Email: mdawoodphysio@gmail.com; Phone: +27 721182565; ORCID ID: 0000-0003-1298-0352

Benita Olivier: Email: Benita.oliver@wits.ac.za, Phone: +27823325776, ORCID ID: 0000-0001-9287-8301

Maria Cochrane: Email: maria.cochrane@smu.ac.za, Phone: +27798950641;

ORCID ID: 0000-0002-6473-5271

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Cricket is a noncontact sport involving repetitive overhead shoulder activities such as the fast bowling action. Even though cricket is considered a low risk sport for injury, injuries do occur in cricketers and more so specifically fast bowlers. These injuries may limit performance as well as playing and or training time (Orchard et al., 2015; Orchard, James, & Portus, 2006). Due to the high biomechanical load placed on fast bowlers they tend to be more susceptible to wear (Arora, Shetty, & Dhillon, 2015).

Bowlers are most frequently affected by shoulder injuries; this is a likely result of their overhead throwing actions (Arora et al., 2015).The causes of shoulder pain most likely include: scapular dyskinesia, glenohumeral internal rotation deficit and weak musculature surrounding the cuff (Aginsky, Lategan, & Stretch, 2004; Arora et al., 2015; Olivier et al., 2016).

Shoulder injuries make up roughly five percent (5%) of all cricket injuries noted in the available literature, which is most likely an underestimation (Arora et al., 2015). The underestimation may be due to the fact that only time-loss injuries were reported on until a consensus statement was released in 2016 (Orchard, Ranson, et al., 2016). It has been noted that cricketers suffering from shoulder pain play through the pain resulting in an unreported injury (Ranson & Gregory, 2008). Only in 2016, researchers representing all fourteen of the cricket playing nations met to discuss the possible changes necessary to be implemented to the consensus statement of 2005, as a result a new consensus statement was published (Orchard, Ranson, et al., 2016). Major changes included; the definition of injuries, injury incidence measures, and characterisation of player role and activity at the time of injury. This meant that prior to 2016 injuries were both underreported and poorly defined.

In a study by Ranson and Gregory (2008) the impact of shoulder injuries on professional cricketers during the 2005 England and Wales first class cricket season was determined.

This was determined by 158 cricketers completing two questionnaires relating to shoulder injuries. The data published from this study showed that cricketers play on with shoulder pain and or injury without missing any training nor match time (Ranson & Gregory, 2008). The majority of the available information regarding the incidence of shoulder pain and injury in fast bowlers is related to elite or junior fast bowlers not taking into consideration non-time-loss injuries (Arora et al., 2015; Davies, Du Randt, Venter, & Stretch, 2008; McLeod et al., 2020; Noorbhai, Essack, Thwala, Ellapen, & Van Heerden, 2012; Ranson & Gregory, 2008). Taking the above mentioned facts into consideration the true incidence of shoulder pain in amateur fast bowlers is unknown.

The rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) situated around the shoulder joint, can become damaged due to overuse during overhead sports such as cricket as well as in the event of poor scapula positioning (Cools, Cambier, & Witvrouw, 2008). Shoulder pain is common amongst athletes performing overhead activities such as throwing and bowling (Arora et al., 2015). Fast bowlers are primarily responsible for bowling which is an overhead activity. In addition, fast bowlers also regularly perform activities such as throwing and fielding during cricket play predisposing them to shoulder pain. Poor scapula positioning whether static or dynamic, resulting from poor muscular control, joint restrictions, muscle length and or imbalance may lead to impaired functioning resulting in shoulder pain. It has been stated that the adequate functioning of the musculature around the shoulder joint can either prevent or rehabilitate shoulder pain in athletes performing repetitive overhead activities such as throwing and bowling in cricketers and specifically fast bowlers (Borsa, Laudner, & Sauers, 2008).

As described the following factors have been shown to be related to shoulder pain and/or injury in overhead athletes; internal and external rotation (ER) shoulder range of motion, muscle activation around the scapula, scapula dyskinesia, shoulder and scapula muscle strength, fatigue and proprioception.

Further research is needed in order to analyse the effect of scapular dyskinesia on participants engaged in overhead sports at an amateur level. Due to the fact that mainly ‘time-loss’ injuries are reported on, the incidence of shoulder pain in amateur

fast bowlers is grossly underestimated and the pre-disposing factors specific to these injuries are relatively unknown.
Scapula dyskinesia is frequently present in overhead athletes with shoulder pain. The measurement of shoulder internal and external rotation may serve the purpose of predicting injury although this needs to be investigated.

There are 12 teams in the Northern Cricket Union (NCU) Premier Cricket League (PCL). Each of these teams consist of four to seven fast bowlers (FB). The Northern Cricket Union Premier Cricket League is the highest level of club (amateur) cricket played in the Gauteng Province. This is the platform from which many professional cricketers are selected. The training regimens are inconsistent amongst teams. The majority of cricketers have highly individualised training programmes as the individual responsibilities and or roles vary between cricketers. Therefore, each cricketer needs to be examined and evaluated as an individual.

The researcher has found no research, specifically in amateur fast bowlers, (Chapter 2) regarding the incidence of shoulder pain (time loss and non-time loss injuries) in amateur fast bowlers nor the associated factors to shoulder pain and or injury in amateur fast bowlers. There is also no exercise programme available in order to address the associated factors to shoulder pain in amateur fast bowlers and prevent injury in amateur fast bowlers.

1.2 PROBLEM STATEMENT

Injury, including shoulder pain, is common amongst athletes performing repetitive overhead activities such as amateur fast bowlers (Premier League Fast Bowlers). There are 12 teams in each of the six Premier Leagues with squads of up to 22 players. Training load, -type and -intensity as well as demographic factors are thought to be predisposing to shoulder pain in athletes who consistently perform overhead activities such as amateur fast bowlers. Scapula dyskinesia has been found to be prevalent in overhead athletes with shoulder pain resulting in poor performance and loss of playing and training time. There is no recently published information available regarding the incidence of shoulder pain or the associated factors to shoulder pain in amateur fast bowlers such as Premier League Fast Bowlers (PLFB).

As discussed above and in the literature described in Chapter 2, there are studies related to the incidence of shoulder pain in elite fast bowlers but none that relate to the amateur fast bowler or the Northern Cricket Union Premier Cricket League. The Premier Cricket League is the most physically taxing level of club cricket in the Gauteng Province of South Africa. It is due to the fact that these Northern Cricket Union Premier Cricket League FB play various forms of the game, they work full time or part time, while some are students. They also take part in various other activities such as gym work and sport/hobbies leaving them even more susceptible to injury. Exercise prescription may address the biomechanical factors associated with scapula dyskinesia and shoulder pain yet there is no evidence regarding the development of a preventative exercise programme addressing the biomechanical factors associated to shoulder pain and/or scapula dyskinesia in amateur fast bowlers (De Mey et al, 2017).

1.3 PRIMARY RESEARCH QUESTION/S

What is the incidence of shoulder pain in Northern Cricket Union Premier Cricket League Fast Bowlers (amateur fast bowlers)?

Can a shoulder exercise programme developed by means of a modified e-Delphi effectively address the factors associated to shoulder pain in amateur fast bowlers?

1.3.1 Secondary Research Questions

What are the factors associated to shoulder pain in amateur fast bowlers?

What is the prevalence of scapula dyskinesia in amateur fast bowlers?

1.4 AIM/S OF THE STUDY

The overall aim of the study was to determine the incidence of shoulder pain and develop a biomechanical shoulder impairment exercise programme effective in addressing the factors associated to shoulder pain in amateur fast bowlers.

1.4.1 Objectives of the Study

The objectives of this study were to:

Study 1 (Chapter 3):

1. Determine the incidence of shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

Study 1 (Chapter 3):

2. Determine the prevalence of scapula dyskinesia in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

Study 1 (Chapter 3):

3. Determine the factors associated to shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

Study 2 (Chapter 4):

4. Develop a biomechanical shoulder impairment exercise programme (using a modified e-Delphi technique) to prevent shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

Study 3: (Chapter 5):

5. Test the ability of the biomechanical shoulder impairment exercise programme to address the associated biomechanical dysfunction related to shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

An overview of the thesis (Study 1 to Study 3) is demonstrated in Figure 1 below:

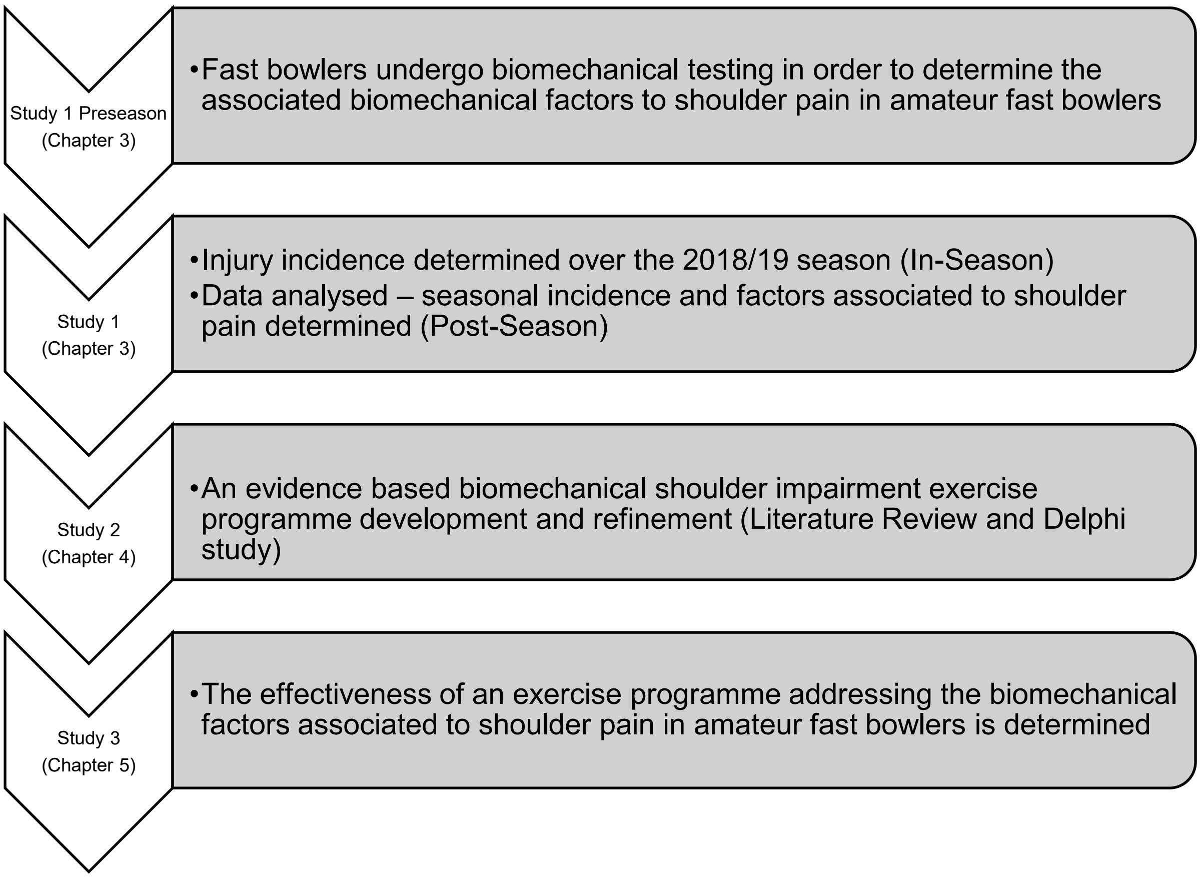


Figure 1.1: Overview of the study

1.4 SIGNIFICANCE OF THE STUDY

Shoulder pain has been described as a common symptom in athletes performing repeated overhead activities (De Mey et al., 2013). Cricketers, specifically fast bowlers, commonly perform such activities in training and matches (Arora et al., 2015).

The majority of the available literature in terms of the incidence of shoulder pain is focussed on elite cricketers or is underestimated due to the fact that non-time-loss injuries are not included. The current study is focussed on shoulder pain in Amateur fast bowlers where both time-loss and non-time-loss injuries are taken into consideration. The knowledge regarding the true incidence of pathology such as shoulder pain in amateur fast bowlers will create awareness towards such injuries leading to focused strategies of treatment and prevention.

Awareness regarding the significant incidence of shoulder pain in amateur fast bowlers displayed in Study 1 (Chapter 3) motivates for further research into injuries and biomechanics in this population. In order to address the treatment and prevention of shoulder pain in this type of sport, associative factors to shoulder pain must be investigated. If the occurrence of risk and predictive factors can be determined, preventative measures may be taken into account such as modifying training regimens, training intensity and training load.

A rehabilitation programme (Chapter 4 and 5) addressing the factors proven to have been associated to shoulder pain was developed with the idea of assessing its ability to prevent shoulder pain in overhead athletes and fast bowlers alike. The exercise programme (intervention) using a pre-post design on a small sample provided preliminary evidence of effectiveness may now be tested further thus leading to a reduction in the occurrence of shoulder pain as this programme will be distributed amongst the majority of fast bowlers in the province and possibility the country. The effectiveness of training programmes could be improved if they could be designed specifically for predetermined athletes with a higher risk to develop shoulder pain/injury, with defined neuromuscular control deficits. The cohort of tests used in this study can be used for pre-screening purposes as such.

The current study provides a successful method for screening and identifying fast bowlers at increased risk of shoulder pain and or injury. If neuromuscular control parameters link directly to shoulder injury and or pain could be identified, more effective screening regimens could be implemented to identify those athletes who are at increased risk for shoulder pain and/or injury. The baseline testing procedures look at the presence of predisposing biomechanical impairments to shoulder pain.

The impairments associated to shoulder pain identified at the baseline testing procedure were addressed via a biomechanical shoulder impairment exercise programme. The baseline testing procedure was done after six weeks of the programme indicating the programme’s effectiveness in addressing the associated biomechanical factors associated to both time-loss and non-time-loss shoulder pain in amateur fast bowlers. This is the only study of its kind assessing South African amateur fast bowlers.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

"*Cricket is a most precarious profession; it's called a team game but, in fact, no one is as lonely as a batsman facing a bowler supported by ten fieldsman and observed by two umpires to ensure that his errors don't go unpunished*." - (Arlott & Allen, 1984).

A formal cricket match can last from a few hours in the afternoon to five days as there are many forms of cricket which means the workload can vary at different levels of play. Cricket is a non-contact sport involving a team of 11 players including a captain, wicketkeeper, several batters and bowlers (Ghosh & Mondal, 2016). Depending on their individualised skill and role, each player is classified as either a specialised batsman or bowler, with some players classified as all-rounders. When their side is not batting, all players act as fielders. Cricketers have many roles including; bowling batting and fielding yet fast bowlers perform all three roles predisposing them to injury (Aginsky et al., 2004; Dhakate Darshana, Yeole, Mhatre, & Khatri, 2019; Gregory, Batt, & Wallace, 2004; Orchard et al., 2015; Schaefer, O'dwyer, Ferdinands, & Edwards, 2018). Each playing-position has its own physical demands, with bowling and fielding having the greatest impact on the shoulder girdle due to the high intensity overhead activity. There are two basic approaches to bowling: fast/medium bowling and spin bowling. The approaches are classified according to the speed of bowling: fast and medium pace bowlers bowl at speeds ranging between 120-150 km/h and 120-130 km/h; and spin/slow bowlers bowl at speeds ranging between 70-90 km/h (Gregory, Batt, & Wallace, 2002).

Cricket is generally considered to be a sport of low injury risk (Orchard, Ranson, et al., 2016). Even though injury is prevalent in fast bowlers and they differ between their levels of play, the majority of the available information regarding cricketers do not differentiate between cricketers with regards to their player role and player level.

Cricket is an overhead sport that requires high intensity, repetitive overhead throwing from the bowler, putting strain on the shoulder joint. It has been noted that information regarding shoulder pain and its associative factors in cricketers is related either to no specific cricketer role or player level or the available information is directly related to elite cricket players only as they have stricter training regimens and medical professionals on staff (Achenbach et al., 2019; Davies et al., 2008; Dutton, Gray, Prins, Divekar, & Tam, 2020; Giles & Musa, 2008; Orchard et al., 2006; Orchard, Kountouris, & Sims, 2016; Peckitt & McCaig, 2019; Sundaram, Bhargava, & Karuppannan, 2012). In order to determine the significance and necessity of investigating shoulder pain in amateur fast bowlers the researcher reviewed the literature related to shoulder pain and the associative factors thereof.

2.2 OUTLINE OF THE LITERATURE REVIEW

The review to follow will focus on describing the literature relating to shoulder pain incidence and its associated factors, as well as pathology in overhead athletes, such as cricketers. Shoulder pain incidence and its relationship with scapula dyskinesia and the investigation thereof will also be discussed. The objectification as well as the identification of associated factors to shoulder pain, through the usage of special tests, will also be discussed.

Various databases and journals were used to search for relevant articles and studies on the current knowledge of shoulder pain in fast bowlers, as well as the use of special tests to objectify the possible associated factors to shoulder pain in patients and or athletes with shoulder pain (See literature review strategy).

The literature review of this study will be split into three subsections. The structure of these three subsections is structurally described using a conceptual framework (Section 2.2 Figure 2.1: Conceptual Framework for the Literature Review). The literature review was structured under the broad banner of the International Classification of Health, Disability and Function (ICF). The ICF was used to develop the conceptual framework and flow of this literature review. The ICF is a framework that may be used to describe and organise information regarding the functioning and impaired functioning of the body in activity. It is widely accepted as the framework that healthcare rehabilitation practices are based on (Wilhite & Shank, 2009).

Looking at shoulder pain in the fast bowler through the lens of the ICF, the impairment in this instance will be shoulder pain, its biomechanical associated factors will be recognised as the personal factors associated to the impairment (shoulder pain) and the activity will be the overhead activity needed for the participation in fast bowling. Subsection 2.1 will describe and appraise the available literature on the incidence and prevalence of shoulder pain in fast bowlers and 2.2 will do the same for the available literature describing the factors associated with shoulder pain in fast bowlers. Subsection 2.3 will discuss the usage of exercises to address the most commonly associated biomechanical factors to shoulder pain.

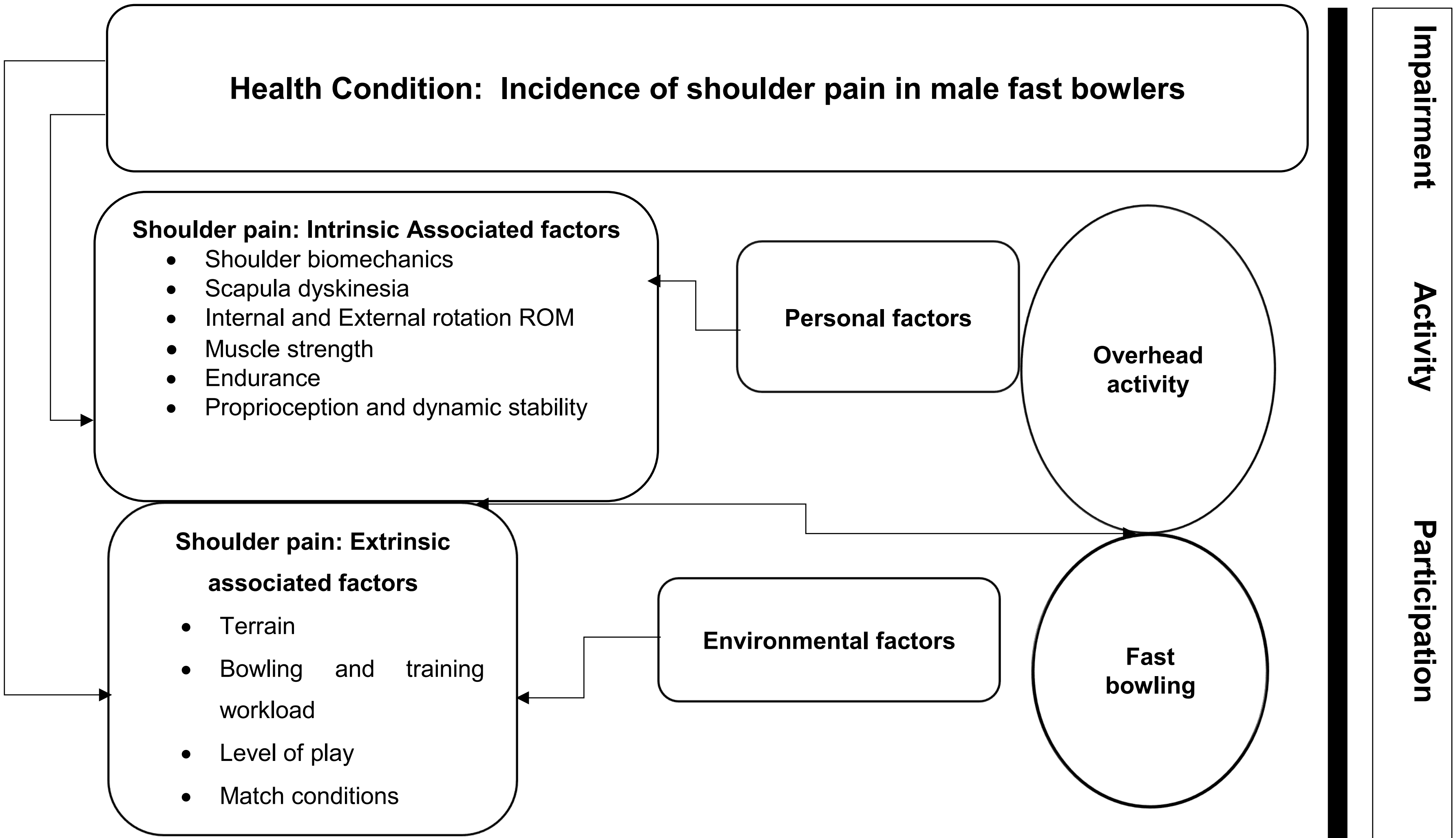


Figure 2.1: Conceptual Framework for the Literature Review – Based on an adapted version of the International Classification of Health, Disability and Function (ICF)

2.3 THE INCIDENCE OF SHOULDER PAIN IN FAST BOWLERS

2.3.1 Introduction

Fast bowlers have been indicated to possess the highest injury prevalence among the different player-roles in cricket (Aginsky et al., 2004; Dhakate Darshana et al.; Orchard et al., 2015). Shoulder pain is highly prevalent in fast bowlers and fast bowlers often play through shoulder pain. The anatomy of the shoulder joint with reference to shoulder pain will be discussed, followed by literature describing the generally accepted manner of defining injury and pain in cricketers and the incidence and prevalence of shoulder pain. The gaps in the current literature will be identified and highlighted throughout the literature review, in order to display what is not known regarding shoulder pain in fast bowlers.

2.3.2 The Anatomy of the Shoulder Joint

The shoulder joint is formed through an articulation between the glenoid fossa of the scapula and the head of the humerus (Behnke, 2012). The shoulder joint is classified as a ball-and-socket joint and, as such, is very mobile. The shoulder joint is commonly unstable due to the fact that the glenoid fossa is shallow and relies on the labrum to maintain joint congruency. The labrum is the structure responsible for making the fossa deeper and moulding the fossa to fit the humeral head (Behnke, 2012) . There are significant changes in the shoulder girdle range of motion (ROM) and strength over time due to the repetitive, overhead activity seen in cricketers (Scott-Hunter, Sims, & Vicenzino, 2015).

Muscles are divided into local stabilisers, global stabilisers or global mobilisers according to their build and function (Comerford & Mottram, 2001). The muscular system of the body, with regards to structural characteristics and anatomy, is divided into two categories, namely the local- and global movement systems. The functions of the stabilising muscles are mainly to support joints, provide stability to the joints in the ideally aligned position and these stability muscles do not activate in the presence of pain (Comerford & Mottram, 2001). One example of this would be the in-activation of the subscapularis muscle in the presence of shoulder pain.

The functions of the stabilising muscles are mainly to support joints and provide stability to the joints in the ideally aligned position. The rotator cuff muscles have local stability and global stability functions (supraspinatus, infraspinatus, teres minor and subscapularis). The local stability function is to keep the head of the humerus in the glenoid fossa, while globally, the rotator cuff muscles maintain the dynamic position of the scapula and GHJ. The shoulder joint is largely dependent of soft tissue structures for its stability, the anatomical structure of the shoulder joint is such that it is at risk of instability due to its physiological make-up and is vulnerable to pain, injury and pathology (Behnke, 2012). Athletes performing overhead throwing activities, such as bowling, have been found to possess differences between the strength of the rotator cuff in the bowling and non-bowling shoulder (Sundaram, Bhargava, et al., 2012). The global mobilisers, however, generate force and are involved in the acceleration of motion and hypertrophy in the presence of pain/dysfunction. The mobilisers have the possibility to loose extensibility due to over activity and hypertrophy. The loss of extensibility results in a shortened mobiliser and a decrease in the range of GHJ motion (Comerford & Mottram, 2001). The differences in strength ratios combined with the overhead activity of bowling causes alterations in muscle strength. During the fast bowling action the internal rotators of the shoulder are responsible for the acceleration before the ball is released and the shoulder external rotators are responsible for deceleration once the ball is released (Sundaram, Bhargava, et al., 2012).

2.3.2.1 Biomechanics of the Shoulder Joint

Due to the high biomechanical load placed on fast bowlers their shoulders tend to be more susceptible to wear (Arora et al., 2015). The biomechanics of overhead throwing involves a combination of the following movements: flexion, abduction and lateral rotation of the shoulder. The action which constitutes a combination of movements, predisposes bowlers and fielders to shoulder injuries, over other playing positions within cricket, due to the stress placed on the joint and surrounding structures during overhead throwing activities (Arora et al., 2015). During the acceleration phase, the internal rotators of the shoulder contract concentrically to move the arm forward, while the external rotators are responsible for the deceleration phase.

The rotator cuff muscles control the dynamic stability of the shoulder joint (Arora et al., 2015). Similarly, there are already large forces across the shoulder joint resulting from high velocity regulating forces during the overhead throwing motion generated from the legs and trunk, which produce a significant level of stress on the muscles, bones and ligaments of the upper extremities (Arora et al., 2015).

2.3.3 The Definition of Injury

It has been noted that cricketers with pain play through the pain, without reporting the pain, resulting in an unreported injury (Ranson & Gregory, 2008). In 2016, researchers representing all fourteen of the cricket playing nations, met to discuss possible changes necessary to be implemented to the consensus statement of 2005. As a result a new consensus statement was published (Orchard, Kountouris, et al., 2016). Major changes to the consensus statement included: the definition of injuries; injury incidence and injury prevalence measures; and characterization of player role and activity at the time of injury (Orchard, Kountouris, et al., 2016). If a player continues to participate in the sport with shoulder pain the player could develop degenerative tendon pathology, altered movement patterns as well as poor stability within that joint, placing the player at risk for chronic shoulder injury. The true incidence factors would be unknown if the fast bowler had not suffered time-loss due to his shoulder pain. Due to the fact that mainly ‘time-loss’ injuries were reported on (up until 2016), the incidence of shoulder pain is grossly underestimated and the pre-disposing factors specific to these injuries are relatively unknown (Arora et al., 2015). See Figure 2.2 below for the definitions of injury. In order to describe what is known regarding shoulder pain in fast bowlers a literature search and review was executed.

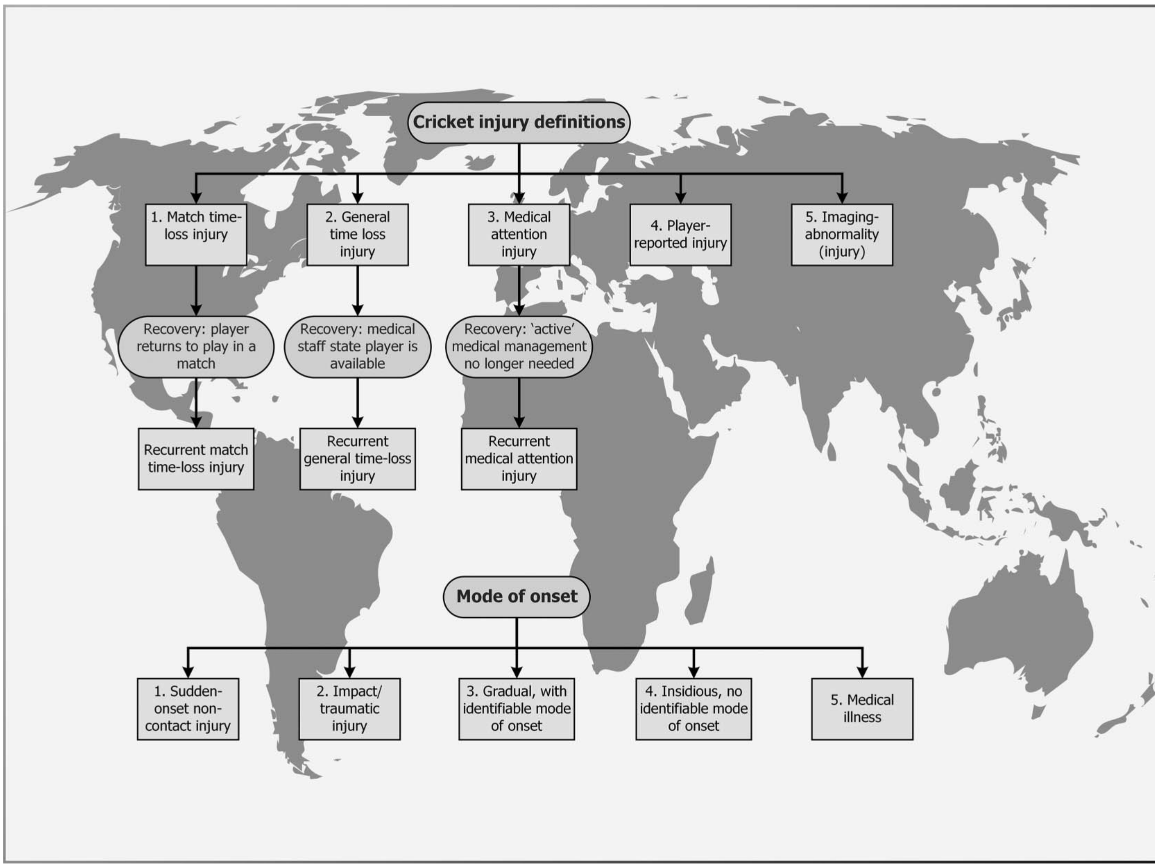


Figure 2.2: Summary of injury definitions (Orchard, Kountouris, et al., 2016)

2.4 SEARCH STRATEGY ONE: SHOULDER PAIN IN MALE AMATEUR FAST BOWLERS.

2.4.1 Literature Search Strategy

In order to obtain relevant information regarding shoulder pain in male amateur fast bowlers, the following search strategy was used:

The databases that were searched included: MEDLINE®, EBSCOHost, Science Direct and SCOPUS. In EBSCOHost a combined search was done in the following databases affiliated with EBSCOHost: CINAHL Complete, Masterfile Premier, SPORTDiscus. The search was done in all full text (all key words were searched for in full throughout complete documents). This journal does not give the option to search via medical subject headings, therefore only keywords apply. Terms qualified with the Text Word field tag were searched in the following fields: title, abstract, MeSH (headings and subheadings including singe words and phrases) and other keywords.

Only articles published in English, limited to humans and after 2012 were included although focus was placed on articles after 2015 as this was the year that the consensus statement accurately defining injury in cricket was released (Orchard, Ranson, et al., 2016). One additional article was sourced from the reference list from the included articles and were used and analysed due to the specific nature of the outcomes of the articles.

The results from the literature search is illustrated in Section 2.4.1, Figure 2.3 and summarized in Table 2.1 below.

Table 2.1: Summary of the search strategies combined.

Databases	Keywords used	Applicable results	Limitations
Medline EBSCOHost Scopus Science Direct Alternative sources: Physiotherapy/physical therapy textbooks	Cricket Cricket sport Shoulder Glenohumeral Overhead Bowl Throw Incidence Prevalence Injury Wound Impingement Pain	± 151 results were found: 31 articles were directly applicable; From the 31, 20 articles were excluded due to unclear methods, content redundancy, participant inconsistencies, the lack of injury definitions, poor differentiation of results per cricketer role, cricketer level of play and age. One additional article was sourced from the reference list from the included articles and were used and analysed due to the specific nature of the outcomes of the article.	English Humans Male The appraisal was focussed on studies published in the years 2012-2020.

From the search strategies illustrated below the included articles for full text review (12 articles) were appraised and summarised in Table 2.2 below.

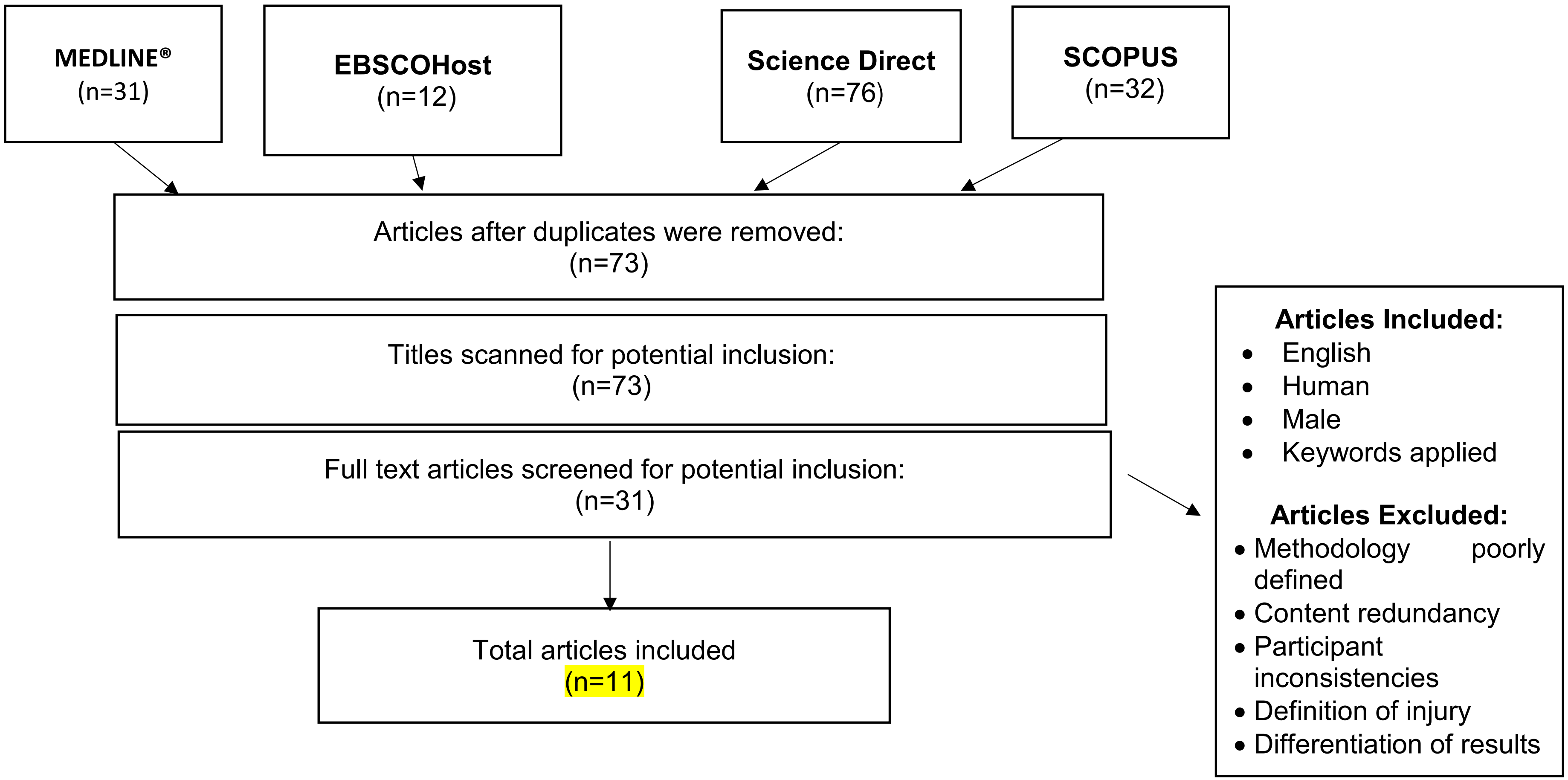


Figure 2.3: Literature search one results

Table 2.2: Brief review and critical analysis of articles relating to the incidence of shoulder pain in fast bowlers

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Arora, M., Shetty, S.H. and Dhillon, M.S., 2015. The shoulder in cricket: What's causing all the painful shoulders?. *Jour nal of Arthroscopy and Joint Surgery*, *2*(2), pp.57-61.	**Method:** Narrative review. **Validity and reliability (quality):** The inclusion and exclusion criterion of the selection of articles were well defined. The search strategies were described in detail. **Limitations:** Two databases were searched. **General comments:** Overall this was useful article describing the known knowledge of shoulder pain in cricketers although the methodology resulted in a lower evidence of article due to the lack of the systematic reviewing process and limited database searches. **Reason for inclusion of an older article:** This was the last article (2015) before the consensus statement was released (2016). It highlights the gaps in the literature up to this point. It is valuable to note that this is one of the last studies summarizing the incidence and causes of shoulder pain in fast bowlers before the consensus statement was released. The authors also note the gross underestimation of the burden of shoulder pain in fast bowlers and this could be reason alone for incidence studies on fast bowlers including both time-loss and non-time-loss injuries (Arora et al., 2015).	Bowlers are most frequently affected by shoulder injuries (Arora et al., 2015). Shoulder pain incidence has been underestimated in fast bowlers (Arora et al., 2015). A possible theory has been proposed (Section 2.8, Figure 2.7) to describe the cause for shoulder pain in cricketers (Arora et al., 2015).	The injury incidence of shoulder pain as 5% (Arora et al., 2015). **Identified limitations and future research recommendations (Arora et al., 2015)**: The underestimation of shoulder pain in fast bowlers and cricketers in general coupled with evidence for the shortcomings in the literature regarding amateur fast bowlers is noted as gaps in the literature relevant to the objective of literature review one.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Dhakate Darshana, S., Yeole, U., Mhatre, S., & Khatri, S. (2019). *incidence of shoulder injuries amongst fast bowlers*.	**Method:** The authors used a descriptive survey based study design **Validity and reliability (quality):** The inclusion and exclusion criteria was well described although the outcome measures used would be difficult to apply to determine true incidence instead of disability and this makes the results of the study difficult to generalize to the population of male fast bowlers. **Limitations:** The study was done on Indian fast bowlers at the state and district level which is a combination of both elite and amateur fast bowlers, this decreases generalizability of the results even further. The incidence of injury forms part of the main objective of the study yet no injury incidence values are clearly described and the authors make no reference to the consensus statement in 2016 (Orchard, Ranson, et al., 2016). **General comments:** The injury incidence noted is too high in relation to other studies it was described that majority of the fast bowlers surveyed had some form of disability, this is inconsistent when compared to the available literature. The methodology of the studied is flawed, the fast bowlers answered a once of questionnaire yet described the resulting information as injury incidence.	Shoulder injuries are more prevalent in fast bowlers. Bowling action is a contributing factors to shoulder pain (Dhakate Darshana et al., 2019). There is a significant incidence of shoulder injury in fast bowlers (Dhakate Darshana et al., 2019)	The injury incidence of shoulder pain is substantially higher in this study. The age of the fast bowlers surveyed displayed statistically significant differences between age groups. **Identified limitations and future research recommendations (Dhakate Darshana et al., 2019):** The differentiation between injury incidences at the different levels of play is unavailable yet important to distinguish. There is a distinct lack of information regarding the injury incidence of amateur fast bowlers.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Dutton, M., Tam, N., & Gray, J. (2019). Incidence and impact of time loss and non-time-loss shoulder injury in elite South African cricketers: A one-season, prospective cohort study. *Journal of science and medicine in sport*, *22*(11), 1200-1205.	**Method:** Recent and valid longitudinal cohort study over one season. **Validity and reliability (quality):** All cricketers were included. The methodology was followed systematic and consistently. **Limitations:** Unclear exclusion criteria. **General comments:** The authors presented the results and conclusion in a structured understandable manner.	Professional/elite cricketers were studied. Nineteen cricketers sustained a shoulder injury in the season of which 18 were non-traumatic non-time-loss and time-loss injuries (Dutton, Tam, Brown, & Gray, 2019). A detailed description of injury incidence was provided (Dutton, Tam, Brown, et al., 2019). Only 32% of the injuries were time-loss injuries and 68% of the shoulder injuries were non-time-loss injuries (Dutton, Tam, Brown, et al., 2019).	The first study to indicate time-loss and non-time-loss injuries in South African cricketers. These values were identified for all cricketers. Similar study design to our study on male amateur fast bowlers. **Identified limitations and future research recommendations (Dutton, Tam, Brown, et al., 2019)**: This is the only study providing this information for cricketers in South Africa regarding shoulder injury. The study by (Dutton, Tam, Brown, et al., 2019) investigates the incidence of elite cricketers and comprises fast bowlers, spin bowlers, batters and all-rounders. Only elite professional cricketers were included.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Forrest, M. R., Scott, B. R., Hebert, J. J., & Dempsey, A. R. (2018). Injury prevention strategies for adolescent cricket pace bowlers. *Sports medicine*, *48*(11), 2449-2461.	**Method:** The authors provided an exercise-based injury prevention rationale and in doing so they had to investigate the literature regarding the incidence of shoulder pain in adolescent fast bowlers. The authors employed a questionnaire based longitudinal cohort study. **Validity and reliability (quality):** The inclusion and exclusion criterion were clearly described. Physiotherapists administered the questionnaire to all the elite fast bowlers. **General comments:** Shoulder injuries were 4.3% of all the injuries sustained by adolescent fast bowlers.	Shoulder injuries are relatively common in adolescent fast bowlers (Forrest, Scott, Hebert, & Dempsey, 2018). Incidence calculations need to be age specific and level of play specific (Forrest et al., 2018). Injury prevention programmes need to be developed specific to the population being targeted (Forrest et al., 2018).	The information presented indicates a lack of available literature regarding shoulder pain/injury incidence in non-elite fast bowlers. There is also a clear cut difference in the different age groups of fast bowlers and the different levels at which they play at justifying the reasoning behind investigating the underestimated burden of shoulder pain in amateur male fast bowlers.

Article	**Critical review**	**Summary of the main findings relevant to the objective of search strategy one.**	**Relevance to the present study on amateur fast bowlers**
Kumar, S., Kulandaivelan, S., Kaur, J., Chaturvedi, R., Girdhar, B., Singh, V., ... & Kumar, V. (2015). One year prevalence of musculoskeletal disorder among cricket Players in Haryana: A retrospective study. *Strain*, *20*, 36.	**Method:** A retrospective survey was employed to investigate the one-year prevalence of musculoskeletal injuries in male cricketers. A modified injury questionnaire was used. **Validity and reliability (quality):** Retrospective data may lack reliability due to bias and recollection issues. The sample size was 127 male players. Although large enough the inclusion criteria were vague and included a wide array of age groups and player levels making the results difficult to generalize to a specific population i.e. male amateur fast bowlers. The results were neither divided according to age nor were they divided according to player role. **Limitations:** The limitations of the study and recommendations for future studies were not provided.	Shoulder injury prevalence rates for the 12-month period were at 14% of the total injuries observed. This was noted as the joint second highest (along with the ankle injury prevalence rate) (Kumar et al., 2015). Fast bowlers sustained the maximum number of injuries among all the player roles involved (Kumar et al., 2015).	**Identified limitations and future research recommendations(Kumar et al., 2015)**: It is clear that each age group and player role needs to be studied with regards to incidence and prevalence separately. The study also highlights the high number of injuries of the shoulder sustained by cricketers in general as well as the fact that bowlers are most frequently affected by injury. Cricketers were not categorized according to the level of play or cricketer role.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
McLeod, G., O'Connor, S., Morgan, D., Kountouris, A., Finch, C. F., & Fortington, L. V. (2020). Medical-attention injuries in community cricket: a systematic review. *BMJ open sport & exercise medicine*, *6*(1), e000670.	**Method:** A systematic review was employed in order to correlate information on medical-attention attention injuries in community cricketers. **Validity and reliability (quality):** The systematic review had a clear set inclusion and exclusion criteria which was described and followed. The information was precise and presented in a clear understandable manner. The study was valid, higher evidence rated and recent. Bias was discussed and described systematically. **General comments:** The study described evidence, consistent with the available literature that, compared to elite levels of cricket, injury in amateur cricket is much less reported.	More effective injury reporting is required at the level of amateur cricket (McLeod et al., 2020). Junior cricketers had suffered injuries due to mechanisms far different from adult cricketers (McLeod et al., 2020). Thirty-two percent of all injuries to the upper limb were shoulder injuries.	**Identified limitations and future research recommendations (McLeod et al., 2020)**: Non-time-loss shoulder pain is unknown in the amateur cricketer population. Medical attention injuries are better recorded and is in majority of the cases the only instances where injury information is available. Injury reporting and recording in amateur cricketers is limited.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Noorbhai, M. H., Essack, F. M., Thwala, S. N., Ellapen, T. J., & Van Heerden, J. H. (2012). Prevalence of cricket-related musculoskeletal pain among adolescent cricketers in KwaZulu-Natal. *South African Journal of Sports Medicine*, *24*(1).	**Method:** This was a retrospective study. Participants were adolescent cricketers who had to retrospectively recollect injury data. **Validity and reliability (quality):** Inclusion and exclusion criteria were vaguely described. Reliability of the instruments used to collect data was unclear. This introduces bias. **Limitations:** The age criterion of the participants was very wide. This would have decreased generalizability of the data. The results were separated per player role and age. This made this article valuable to be included.	Shoulder injury prevalence was third highest at 17% (Noorbhai et al., 2012). Batters were noted to have the highest prevalence of musculoskeletal pain (30%) with bowlers second (23%) (Noorbhai et al., 2012).	**Identified limitations and future research recommendations(Noorbhai et al., 2012)**: Injury definitions were yet again not used to define the type of pain/injury the cricketers suffered. Poor logging of injuries and pain in cricketers not at an elite level is once again noted. Further longitudinal population, age and player role specific studies were recommended.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Olivier, B., Lala, B., & Gillion, N. (2020). The cricketer's shoulder and injury: Asymmetries in range of movement and muscle length. *The South African Journal of Physiotherapy*, *76*(1).	**Method:** Thirty-two cricketers were monitored for the first three months of a season in this recent study. **Validity and reliability (quality):** The authors specified the inclusion and exclusion criteria although they included both elite and amateur athletes. **Limitations:** The results were neither discussed per age group, player role nor player level. This limited generalizability of the results. The data analysis using effect sizes was clear and supported by relevant literature. **General comments:** The study design was longitudinal and prospective which was a strength. The small sample size was a weakness.	Time-loss injury incidence was noted at 28% which is significantly higher than the literature described in this table indicates(Olivier, Lala, & Gillion, 2020). Non-time-loss injuries can translate in to time-loss injuries (Olivier et al., 2020).	**Identified limitations and future research recommendations(Olivier et al., 2020)**: The study had a mixed population of amateur and elite athletes. All player roles were combined not allowing true incidence statistics for fast bowlers There is no South African study quantifying the incidence of shoulder pain in male amateur fast bowlers.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Orchard, J. W., Kountouris, A., & Sims, K. (2016). Incidence and prevalence of elite male cricket injuries using updated consensus definitions. *Open access journal of sports medicine*, *7*, 187.	**Method:** Elite cricketers were monitored over a decade retrospectively using available data. **Validity and reliability (quality):** Injury definitions via the consensus statement was applied (Orchard, Ranson, et al., 2016). The inclusion and exclusion criterion was clearly described and effective for generalization on the elite male cricketing population.	The annual injury incidence was 64 injuries/100 players per season (Orchard, Kountouris, et al., 2016). Fast bowlers average injury prevalence was much higher than other positions (20.6%) (Orchard, Kountouris, et al., 2016). Four new shoulder injuries per 100 players per year were noted (Orchard, Kountouris, et al., 2016)	**Identified limitations and future research recommendations (Orchard, Kountouris, et al., 2016)**: As with the majority of the available literature, only elite cricketers were investigated. These cricketers' injury information is readily available usually on online databases. Injured areas were not separated by each cricketer's role (e.g. bowler, batter, fielder and wicket keeper).

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Pardiwala, D. N., Rao, N. N., & Varshney, A. V. (2018). Injuries in cricket. *Sports health*, *10*(3), 217-222.	**Method:** A clinical review investigating the incidence and prevalence of injuries in cricketers. **Validity and reliability (quality):** Cricketers playing at all levels were included in this clinical review and therefore, the results are not generalizable to a certain level of play or cricketer role. **Limitations:** Only one database was searched (PubMed) and the articles reviewed focussed on all sites of injury). The inclusion and exclusion criterion were vaguely defined. The authors did separate player role per injury although the results of all the types of bowling (spin, medium and fast) were grouped together.	From the low evidence level clinical review the authors noted that 41.3% of all injuries in cricket is due to bowling (Pardiwala, Rao, & Varshney, 2018). The incidence of shoulder injury is consistent with the articles summarized in this table (23%). The prevalence of injuries in cricketer has increased in the last decade (Pardiwala et al., 2018).	**Identified limitations and future research recommendations(Pardiwala et al., 2018):** The study had included a mixed population of amateur and elite athletes in the studies included in the one-journal search clinical review of the literature. All player roles were combined not allowing true incidence statistics for fast bowlers. There is no study quantifying the incidence of shoulder pain in male amateur fast bowlers.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy one.	Relevance to the present study on amateur fast bowlers
Ranson, C. and Gregory, P.L., 2008. Shoulder injury in professional cricketers. *Physical Therapy in Sport*, *9*(1), pp.34-39.	**Method:** Physiotherapists from 18 professional teams in Wales and England administered two reliable injury surveillance questionnaires to all the contracted players of the 2005 season. **Validity and reliability (quality):** Response rates were low (42%) and the handling of this was not explained. The inclusion and exclusion criteria was well defined and the data was representative of professional cricket in England and Wales. **Limitations:** The questionnaires were only administered at two points of the season thus introducing recall bias to the study.	The seasonal injury incidence was 23%in the 2005 season (Ranson & Gregory, 2008). Time-loss injuries were noted at 1.7%. Eighteen percent of cricketers felt shoulder pain while throwing. Cricketers commonly play on even though they are inflicted with shoulder pain thereby decreasing performance (Ranson & Gregory, 2008). This is one of the only studies presenting data for both time-loss and non-time-loss injuries.	**Identified limitations and future research recommendations(Ranson & Gregory, 2008):** Only professional cricketers were investigated. Non-time-loss injuries were only included if they had an effect on the cricketers activities of daily living or performance, these are not true non-time-loss injuries (Orchard, Ranson, et al., 2016). The questionnaires were only administered twice during the season thus introducing recall bias and limiting the accuracy of the incidence percentages.

From the 12 articles summarised, the majority of included studies focussed on either elite and or professional cricketers and or youth/junior cricketers (Arora et al., 2015; Davies et al., 2008; Dutton, Tam, & Gray, 2019; Forrest et al., 2018; McLeod et al., 2020; Noorbhai et al., 2012; Ranson & Gregory, 2008).

Shoulder pain has been consistently described as one of the most commonly injured areas in fast bowlers (Dhakate Darshana et al., 2019; Dutton, Tam, & Gray, 2019; Noorbhai et al., 2012). Fast bowlers have been described as one of the most commonly injured player roles (Dhakate Darshana et al., 2019; Dutton, Tam, & Gray, 2019; Noorbhai et al., 2012).

A limiting factor in the volume of available research is that the majority of studies do not differentiate between incidence rates at various player roles, age and/or cricketer level of play (Dhakate Darshana et al., 2019; Kumar et al., 2015; Noorbhai et al., 2012; Olivier et al., 2020; Pardiwala et al., 2018; Ranson & Gregory, 2008). The only shoulder injury specific study providing time-loss and non-time-loss injury incidence information for adult South African male cricketers investigates the incidence of elite cricketers and comprises of fast bowlers, spin bowlers, batters and all-rounders (Dutton, Tam, Brown, et al., 2019). There are no studies investigating both time-loss and non-time-loss injury incidence reporting the incidence of shoulder pain in South African amateur fast bowlers. This could be explainable due to the fact that elite cricketers' information are all stored on an online database and makes injury tracking relatively simple when compared to amateur cricketers who have no real time-loss and non-time-loss injury incidence information in South Africa.

A summary of the key findings applicable to the objectives of the first literature review is summarised in Figure 2.4 below.

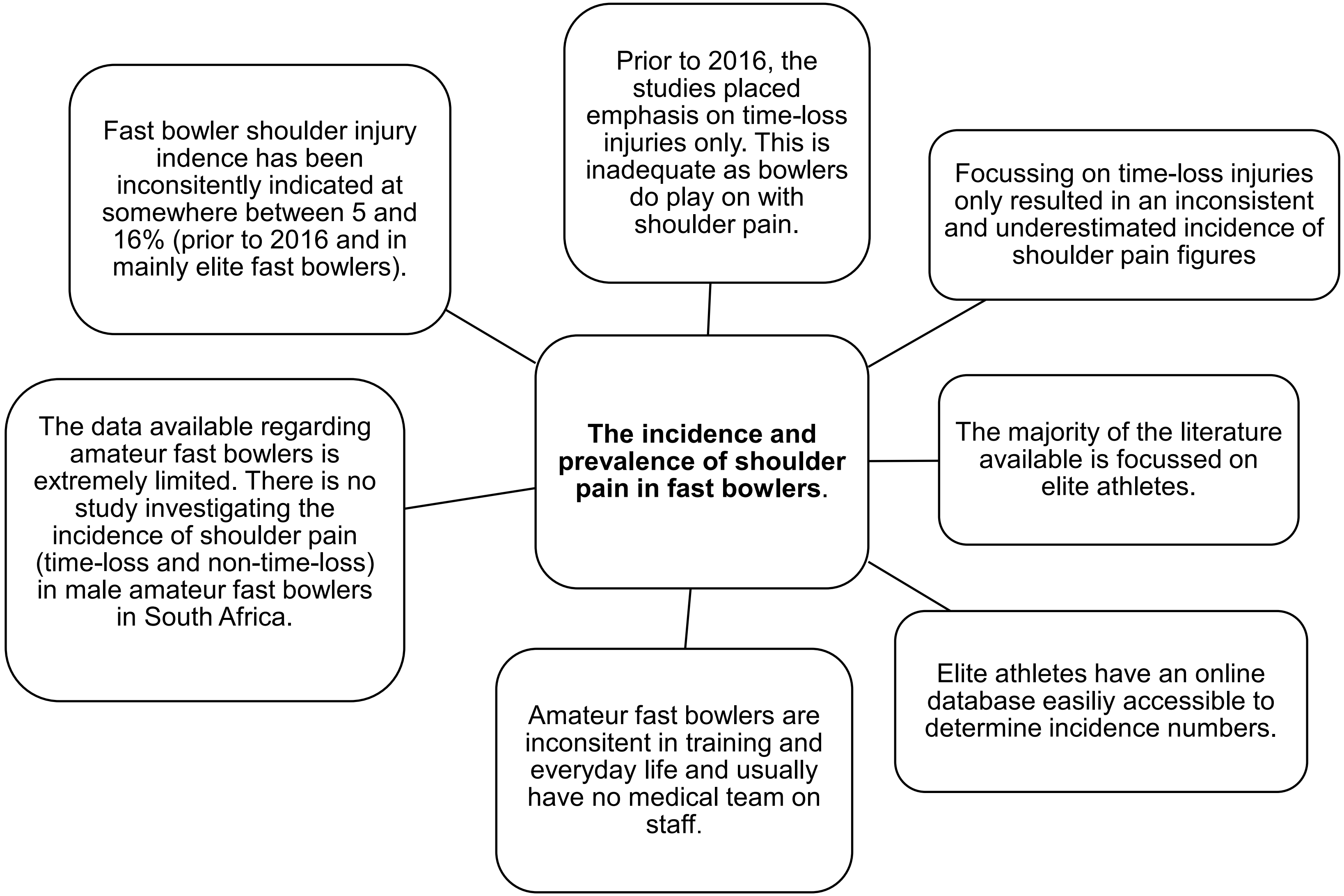


Figure 2.4: A summary of the key findings from the full text review on shoulder injury prevalence and incidence

2.5 HEALTH CONDITION: SHOULDER PAIN IN AMATEUR FAST BOWLERS

As indicated in Section 2.4, Table 2.2 above, fast bowlers suffer from shoulder pain and the burden of shoulder pain is clearly underestimated (Arora et al., 2015; Cools, Witvrouw, Mahieu, & Danneels, 2005; Dhakate Darshana et al., 2019; Dutton, Tam, & Gray, 2019; Ranson & Gregory, 2008). Arora et al. (2015) undertook the objective to summarize the available literature on the possible mechanism of shoulder pain among cricketers due to the gross underestimation of the burden of shoulder pain in this population.

2.5.1 The Incidence and Prevalence of Shoulder Pain in Cricketers

Although cricket is considered a low risk sport for injury, injuries do occur in cricketers and these injuries may limit performance as well as playing and or training time (Orchard, Kountouris, et al., 2016). It has been reported that shoulder injuries make up approximately five percent (5%) of all the injuries cricket players experience (Arora et al., 2015). The estimated 5% is most likely an underestimation, as only time-loss injuries were reported in the available literature, until a consensus statement was released in 2016 (Orchard, Ranson, et al., 2016). In a study by Ranson and Gregory (2008), injury incidence of shoulder injuries in professional cricketers during the 2005 England and Wales first class cricket season was determined (Ranson & Gregory, 2008). The seasonal injury incidence was 23% in the 2005 season (Ranson & Gregory, 2008). Time-loss injuries were noted at 1.7%. Eighteen percent of cricketers felt shoulder pain while throwing (Ranson & Gregory, 2008). This is one of the only studies presenting data for both time-loss and non-time-loss injuries. The objectives were determined by 158 cricketers completing two questionnaires relating to shoulder injuries. In the study by Kumar et al. (2015) it was determined that the second most common site of injury is shoulder (14%). The authors used a survey to retrospectively investigate the one-year prevalence of musculoskeletal injuries in male cricketers. It had been found that fast bowlers sustained the maximum number of injuries among all the player roles involved (Kumar et al., 2015). The fact that fast bowlers sustained the maximum number of injuries among all player roles is supported in the available literature (Arora et al., 2015; Dhakate Darshana et al., 2019; Ranson & Gregory, 2008). Arora et al. (2015) executed a narrative review to find out what the causes of the painful shoulders are and found that bowlers are most frequently affected by shoulder pain and shoulder incidence is estimated at 5%, which is an underestimation. Dhakate Darshana et al. (2019) indicated that there is a significant incidence of shoulder injuries in fast bowlers (33% - 38%) although they did not classify injuries according to the generally accepted consensus and the identified incidence was abnormally higher that what has been found in the literature.

The majority of the studies identified in the literature search did not include non-time-loss injuries (Arora et al., 2015; Davies et al., 2008; McLeod et al., 2020; Noorbhai et al., 2012; Ranson & Gregory, 2008). The exclusion of non-time-loss injuries whether unintentional or not, could be the major causative factor for the underestimation of shoulder pain in fast bowlers as bowlers frequently bowl on even when they are inflicted with shoulder pain (Ranson & Gregory, 2008). In 2016, researchers representing all fourteen of the cricket playing nations updated the consensus statement of 2005 (Orchard, Kountouris, et al., 2016). The implementation of the new consensus statement could contribute to more accurate incidence reporting and greater knowledge regarding injuries that cricket player's experience. In addition to the limited injuries that were reported until 2016, underreporting of shoulder injuries may also account for the underestimated incidence of shoulder injuries in cricket players (Orchard, Kountouris, et al., 2016). The definition for injury for future studies need to include both time-loss and non-time-loss injuries (Orchard, Ranson, et al., 2016) this will increase the number of injuries captured, and also ensure that injuries with potential future time-loss consequences are not missed. The incidence of injury in cricketers performing all player roles over a period of 10 years was investigated (Orchard et al., 2006). The incidence of injury described equated to an average of 1% of the injuries noted over the span of the 10 years included in the study. Shoulder injury incidence was indicated at approximately 5% of all the injuries sustained in cricket (all player roles) and noted this as a gross underestimation (Arora et al., 2015). In a study by Ranson and Gregory in 2008 both time-loss and non-time-loss injuries were noted as 1.7% and 23% respectively (Ranson & Gregory, 2008). A one of a kind South African shoulder pain incidence study including both time-loss and non-time-loss injuries indicated that 18% of elite South African cricketers, which again included all player roles not differentiating between fast bowlers, spin bowlers, all-rounder and batter, sustained a shoulder injury (Dutton, Tam, & Gray, 2019).

With reference to the information regarding the prevalence and incidence of time-loss and non-time-loss injuries above and in Section 2.4, Table 2.2 above; studies including time-loss injuries only indicated shoulder injury prevalence and incidence figures at under 5% (Arora et al., 2015; Davies et al., 2008; McLeod et al., 2020; Noorbhai et al., 2012). Studies including either a combination of non-time-loss injuries and time-loss injuries or non-time-loss injuries alone indicated incidence at prevalence rates well over 20% (Dutton, Tam, & Gray, 2019; Ranson & Gregory, 2008). This clearly indicates the underestimation of the burden of shoulder pain (when the non-time-loss injuries are not accounted for).The information described by Ranson and Gregory also justify the need to look into a combination of both time loss and non-time-loss injuries (Ranson & Gregory, 2008).

Cricketers play on with shoulder pain and or injury without missing any training nor match time (Kumar et al., 2015; Ranson & Gregory, 2008). Olivier et al. (2020) investigated the associated factors to shoulder injury in elite cricketers and what was found was that cricketers with non-time-loss shoulder pain were more likely to develop time-loss injuries and decreased performance. Fast bowlers were not categorised and all player roles were included. The fact that fast bowlers play and train through pain also justifies the need to include both time-loss and non-time-loss injuries when assessing the true incidence of shoulder pain. Due to the fact that only time-loss injuries were previously reported on, many of the injuries suffered by cricketers are not recorded. The cricketers with non-time-loss injuries were not identified. In turn, the non-identified injuries would lead to the underreporting of shoulder injury and incorrect incidence rates of shoulder pain. The early detection of shoulder pain can prove vital in the early management and prevention of time-loss injury in cricketers.

2.5.2 Conclusion, the Incidence and Prevalence of Shoulder Pain

In summary, from the literature searches done and the available evidence described and appraised, the literature regarding injuries in amateur male fast bowlers is limited. Prior to the 2016 consensus statement the majority of the studies placed focus on time-loss and medical-attention injuries only, however, it has been found that fast bowlers do play-on with shoulder pain. Bowlers playing through pain lead to an underestimated, underreported and inconsistent array of shoulder prevalence and incidence figures. In addition to the above, the majority of the literature has placed focus on elite athletes. Elite athletes are focussed on, due to the fact that they are easily accessible, usually possess a medical team on staff and are monitored via online databases. Amateur athletes on the other hand, have no medical team on staff, no online logging of injuries or databases to serve the purpose of injury monitoring. This results in making the tracking of injury incidence through longitudinal cohort study designs significantly more difficult and therefore decreasing the amount of information available regarding injury incidence in amateur fast bowlers. Despite the fact that amateur fast bowlers are inconsistent in their training and everyday activity regimens further predisposing them to injury and pain, there is little to no information regarding injury incidence in amateur fast bowlers. One needs to take into account that elite fast bowlers are specialised athletes who earn a living from playing cricket and have an online platform where incidence rates are readily available for capturing and this is evident in the lack of information available regarding the true incidence of amateur male fast bowlers in South Africa.

In conclusion the evidence available regarding shoulder incidence and prevalence in fast bowlers is focussed on; the elite cricketer, the adolescent elite cricketer, time-loss injuries alone or other joints except the shoulder joint. There are no available shoulder injury incidence figures for amateur male fast bowlers in South Africa.

2.6 THE FACTORS ASSOCIATED WITH SHOULDER PAIN (PERSONAL AND ENVIRONMENTAL FACTORS AND ACTIVITY

2.6.1 Introduction

In Subsection 2.1, the knowledge regarding the incidence and prevalence of shoulder pain was described as being common among cricketers performing overhead activities such as throwing and bowling (Arora et al., 2015). In this subsection the personal factors contributing to shoulder pain were examined and expanded on and the environmental factors were described and not expanded on, as it falls outside the scope of the current study. The activity (fast bowling) will be discussed as well with reference to shoulder pain and the contributing factors thereof.

The same structure of the conceptual framework, described in Section 2.1, will be followed in relation to the ICF. The focus of this section of the literature review was to explore the personal factors associated with shoulder pain. This subsection aimed to review and summarise the literature regarding the biomechanical associated factors to shoulder pain in fast bowlers (personal factors). This was done by means of performing a literature search which is described below. The results were filtered and described. The information that was deemed applicable to the aims of this subsection is summarised in Section 2.6, Table 2.3. The main contributing factors to shoulder pain was then described and the gaps and recommendations were highlighted with reference to the aims of the study.

2.6.2 Search strategy two: Factors Associated to Shoulder Pain in Amateur Male Fast Bowlers

Database search strategy

The databases that were searched included; MEDLINE®, EBSCOHost, Science Direct and SCOPUS Keywords were searched in all text. Terms qualified with the Text Word [tw] field tag were searched in the following fields: title, abstract, MeSH (headings and subheadings including singe words and phrases) and other keywords.. Only articles published in English, limited to humans and in the last 10 years (after 2010). In EBSCOHost a combined search was done in the following databases affiliated with EBSCOHost: CINAHL Complete, Masterfile Premier and SPORTDiscus. The search was done in all text. Search in MeSH terms was not available for this journal.

The results from the literature search is illustrated in Section 2.6.2 Figure 2.5 above and summarized in Table 2.3 below.

Table 2.2: Summary of the search strategies combined.

Databases	Keywords used	Applicable results	Limitations
Medline, EBSCOHost, Scopus and science direct Alternative sources: Physiotherapy/physical therapy textbooks	Cricket Cricket sport Shoulder Glenohumeral Injury Wound Impingement Pain Associated factors Risk factors Contributing factors	± 213 results were found, of which only 27 was directly applicable; from the 27, 17 articles were excluded due to unclear methods, content redundancy, information, participant inconsistencies, the lack of injury definitions, poor differentiation of results per cricketer role, cricketer level of play and age.	English Humans Male Publication date restrictions: 2010-2020.

The results from the literature search is illustrated in Section 2.5, Figure 2.5. From the search strategies illustrated above the included articles for full text review (10 articles) were appraised and summarised in Table 2.4.

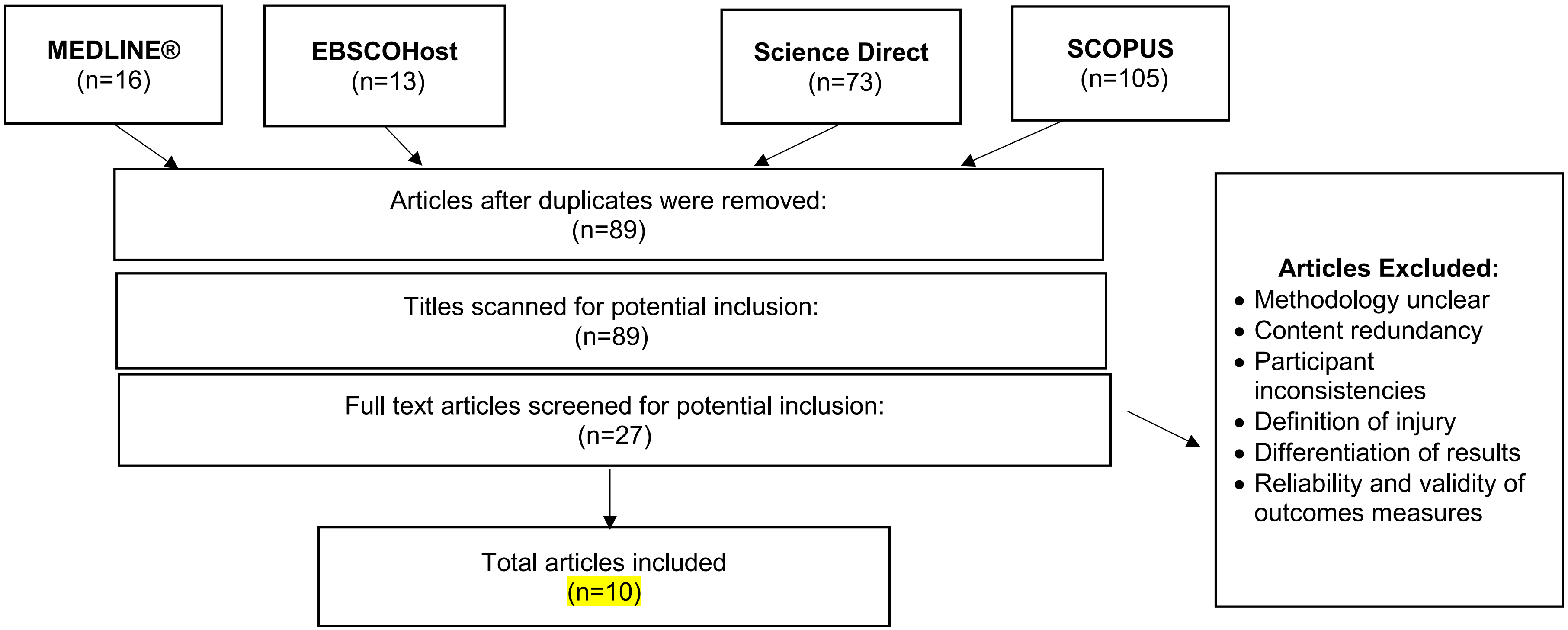


Figure 2.5: Literature search strategy two results

The manner in which articles were excluded is described in Figure 2.5. The study design of the included manuscripts were not used as part of the exclusion criteria due to the limited availability of articles already meeting the inclusion criterion.

Table 2.4: Brief review and summary of articles relating to the associated factors to shoulder pain.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Achenbach, L., Laver, L., Walter, S. S., Zeman, F., Kuhr, M., & Krutsch, W. (2019). Decreased external rotation strength is a risk factor for overuse shoulder injury in youth elite handball athletes. *Knee Surgery, Sports Traumatology, Arthroscopy*, 1-10.	**Method:** A longitudinal cohort study assessing elite youth handball players over a season. Baseline tests were compared to in-season questionnaires. **Validity and reliability (quality):** Consistency regarding the submission and report back of the questionnaires were lacking. Injury definitions were not according to the latest injury definition or any definition related (Orchard, Ranson, et al., 2016). **Limitations:** Bias was not discussed although it was not evident. Clear methodology and ethical annotations. Large sample size allowing generalizability of the results.	Shoulder strength and glenohumeral internal rotation deficit (GIRD) were identified as risk factors for shoulder (Achenbach et al., 2019).	Pre-season baseline tests may aid the identification of risk factors for shoulder injuries in overhead athletes. Risk factors identified for shoulder injury in elite youth handball players. **Identified limitations and future research recommendations (Achenbach et al., 2019):** Only one rater assessed muscle strength. Scapula analyses on field have conflicting results No definition of injury was used. Endurance, proprioception and dynamic stability was not assessed. Study was on youth elite handball players

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Anand, P. C., Khanna, G. L., Chorsiya, V., & Rana, A. (2017). Relationship between Shoulder Strength and Bowling Speed in Cricket Bowlers. *Journal of Exercise Science & Physiotherapy*, *13*(1), 12.	**Method:** Low evidence cross-sectional study. **Validity and reliability (quality):** The inclusion and exclusion criteria were vaguely described. The methodology regarding the testing of muscle strength was well described. **Limitations:** The response rate and the adjustments thereof were not described. **General comments:** Effect size calculations used	Range of motion (ROM) of internal and external rotation of the glenohumeral (GHJ) as well as muscle strength around the scapula correlates with bowling speed (Anand, Khanna, Chorsiya, & Rana, 2017)	**Identified limitations and future research recommendations (Anand et al., 2017):** This was a once off cross-sectional study. The bowling speed was the only outcome investigated and it was only looked at once, no follow-up regarding shoulder pain nor accuracy was investigated.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Asker, M., Brooke, H. L., Waldén, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018). Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. *British journal of sports medicine*, *52*(20), 1312-1319.	**Method:** A systematic review. Using only high evidence literature to conduct the review. **Validity and reliability (quality):** A stringent selection process to include articles was clearly described. Bias was well accounted for and described. Clear comparative findings were described	The investigated potential risk factors for shoulder pain in overhead sports are mostly non-modifiable. There is limited evidence for the effect of shoulder injury prevention measures in overhead sports (Asker et al., 2018). Training workload, shoulder range of motion, gender, muscle strength of the external rotators, scapula stabilisers, and the level of play have had some indication of association to the development of shoulder pain in overhead athletes (Asker et al., 2018)	**Identified limitations and future research recommendations (Asker et al., 2018):** Many studies do not make accurate estimations of power resulting in studies not reaching statistical significance. Future studies need to take all potential confounding factors into consideration in the analyses of associations between the exposure and the outcome (shoulder pain. Stepwise algorithms should not be used when defining confounding factors as they place too much emphasis on the p-value. Clear injury definitions should be distinguished prior to the commencement of each future study Studies should include baseline measurements at the commencement of a cohort study to identify confounders to shoulder pain.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Forrest, M. R., Hebert, J. J., Scott, B. R., Brini, S., & Dempsey, A. R. (2017). Risk factors for non-contact injury in adolescent cricket pace bowlers: a systematic review. *Sports medicine*, *47*(12), 2603-2619.	**Method:** This was a systematic review searching seven databases. **Validity and reliability (quality):** Risk bias was assessed objectively. The inclusion and exclusion criterion was described in detail. The injury definitions according to the international consensus statement was clearly stated (Orchard, Ranson, et al., 2016). **General comments:** The classification of injury was (contact or non-contact) was consistent with previous approaches.	The technique and type of bowling action was listed as some of the main risk factors for injury in fast bowlers. Shoulder counter-rotation (i.e., excessive shoulder rotation was also noted as a risk factor for injury. Bowling and training workload also contributed to shoulder pain in fast bowlers (Forrest, Hebert, Scott, Brini, & Dempsey, 2017).	**Identified limitations and future research recommendations(Forrest et al., 2017):** Majority of the studies included elite male fast bowlers from Australia. Majority of the studies placed focus on the lumbar and pelvic regions of the fast bowlers. Clinical and study heterogeneity limited the study. Recall bias was prevalent in the majority of the studies included. Injury definitions were inconsistent among the studies making it difficult to generalise the results outside of the relevant cohort. The authors recommended that future cohort studies in fast bowlers include injury-free fast bowlers at the baseline.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Giles, K., & Musa, I. (2008). A survey of glenohumeral joint rotational range and non-specific shoulder pain in elite cricketers. *Physical therapy in Sport*, *9*(3), 109-116.	**Method:** An observational study assessing elite cricketers using a questionnaire and range of motion measurements. **Validity and reliability (quality):** No injury definition was given and the association to pain was vague **Limitations:** The inclusion criteria were vague. Bias and limitations were discussed in detail. The methodology and data analysis was described in detail.	It has been concluded from this study that the problem of shoulder pain amongst elite cricketers has been previously underestimated. Internal rotation deficit of the shoulder has been underestimated as an associated factor to the development of shoulder pain and need further investigation.	**Identified limitations and future research recommendations(Giles & Musa, 2008):** The study population involved only elite cricketers. Injury definitions were not according to any consensus statement. The injuries were not classified according to; player role, bowler type and age group. Further study is needed to determine the relationship between range of motion and shoulder pain in different player levels and bowing types i.e. amateur fast bowlers (like in our study).

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Keller, R. A., De Giacomo, A. F., Neumann, J. A., Limpisvasti, O., & Tibone, J. E. (2018). Glenohumeral internal rotation deficit and risk of upper extremity injury in overhead athletes: a meta-analysis and systematic review. *Sports health*, *10*(2), 125-132.	**Method:** A systematic review and meta-analysis was executed. **Validity and reliability (quality):** The authors followed a strict well described inclusion and exclusion criteria. Bias was described and well indicated. Clear objectives were followed through by a well thought out and executed methodology.	The results favoured injury in overhead athletes with glenohumeral internal rotation deficit, decreased internal rotation of the glenohumeral punch and increased external rotation range of motion.	**Identified limitations and future research recommendations(Keller, De Giacomo, Neumann, Limpisvasti, & Tibone, 2018):** The measurement of range of motion was not uniform among the methodologies of the studies included in the systematic review.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Olivier, B., Lala, B., & Gillion, N. (2020). The cricketer's shoulder and injury: Asymmetries in range of movement and muscle length. *The South African Journal of Physiotherapy*, *76*(1).	**Method:** A prospective longitudinal cohort study design was followed. **Validity and reliability (quality):** Clear injury definitions were used for shoulder pain according to the consensus statement (Orchard, Ranson, et al., 2016). Non-time-loss injuries were included. Inclusion and exclusion criterion was clearly described.	Increase in external rotation ROM, decreased internal rotation ROM and past injury have some association to shoulder pain (Olivier et al., 2020).	**Identified limitations and future research recommendations(Olivier et al., 2020):** The participants were yet again elite cricketers only. The participants studied were of all player roles (batters, bowlers, spin bowlers etc.)

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Peckitt, J., & McCaig, S. (2019). In-season variation in shoulder strength, movement and pain in elite cricketers: A cohort study. *Physiotherapy Practice and Research*, *40*(2), 105-112.	**Method:** A longitudinal cohort study design was employed. **Validity and reliability (quality):** The authors offered no description of the exclusion criteria adopted in the methodology of the study. No definition of injury included in the identification of shoulder injury. The limitations and conclusions were accurately and clearly described. **Limitations:** Effect sizes were calculated and explained. The authors described the methodology in detail however, inconsistent follow-up procedures were executed.	Cricketers demonstrated significant increases in total arc range of motion. They also display a decreased external rotation and internal rotation strength ratio (Peckitt & McCaig, 2019). Cricketers may exhibit their own strength and ROM profiles (Peckitt & McCaig, 2019).	**Identified limitations and future research recommendations (Peckitt & McCaig, 2019):** One third of all players tested reported playing with shoulder pain at some stage during season this indicated that non-time-loss shoulder pain is highly prevalent in cricketers. Identified limitations and future research recommendations(Peckitt & McCaig, 2019): The participants were once again elite cricketers. No detailed association between impairments were analysed.

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Sundaram, B., Bhargava, S. K. N., & Karuppannan, S. (2012). Glenohumeral rotational range of motion differences between fast bowlers and spin bowlers in elite cricketers. *International journal of sports physical therapy*, *7*(6), 576.	**Method:** A simple cross-sectional study design was utilized. Fast bowlers' rotational range of motion of the shoulder joint was compared to spin bowlers' rotational range of motion. **Validity and reliability (quality):** The inclusion and exclusion criteria was clearly specified. **Limitations:** The two groups were not in equal proportions although similar in demographics and number. The bowlers were described as elite although no further information was given regarding this.	The external rotation difference was decreased in fast bowlers when compared to spin bowlers (Sundaram, Bhargava, et al., 2012). Both fast and spin bowlers demonstrated a decreased internal rotation range of motion of the shoulder when comparing the dominant and non-dominant arms (Sundaram, Bhargava, et al., 2012).	Fast bowlers have increased glenohumeral external rotation and decreased glenohumeral internal rotation in their dominant/bowling shoulders (Sundaram, Bhargava, et al., 2012).

Article	Critical review	Summary of the main findings relevant to the objective of search strategy two.	Relevance to the present study on amateur fast bowlers.
Struyf, F., Nijs, J., Meeus, M., Roussel, N. A., Mottram, S., Truijen, S., & Meeusen, R. (2014). Does scapular positioning predict shoulder pain in recreational overhead athletes?. *International journal of sports medicine*, *35*(01), 75-82.	**Method:** A longitudinal cohort study design was executed. Athletes completed a baseline testing session assessing the scapula followed up by a two year later follow-up questionnaire. **Validity and reliability (quality):** The inclusion and exclusion criteria allowed for previous pain and surgery as long as no pain was present in each athlete over the previous 24 hours. This could cause adaptations in the scapula which would in turn influence the validity of the results as shoulder pain has been labelled as a risk factor for future shoulder pain. **Limitations:** A poor response rate to the questionnaires at the follow up was noted yet the manner of addressing this was neither discussed nor described.	Tilting, winging and decreased upward rotation of the scapula was more prevalent in the athletes who developed shoulder pain (Struyf et al., 2014).	**Identified limitations and future research recommendations(Struyf et al., 2014):** There were no injury definitions used for differentiation between groups of the study. The athletes were labelled as recreational overhead athletes with no further specifications of the player level at the sports that these athletes participated in. There were no fast bowlers included in the study. The reliability and validity of the techniques used to evaluate the scapula is questionable.

From the 10 articles summarised and reviewed in Section 2.6.2, Table 2.4, the associated biomechanical factors to shoulder pain in athletes performing overhead activities were identified as: shoulder strength deficits; glenohumeral internal rotation deficit (GIRD); an increase in shoulder external rotation ROM; a decrease in shoulder internal rotation ROM; fatigue; proprioception and poor scapula positioning including scapula dyskinesia (Achenbach et al., 2019; Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Asker et al., 2018; Dabholkar, Utekar, & Dabholkar; Ghosh & Mondal, 2016; Hickey, Solvig, Cavalheri, Harrold, & Mckenna, 2018; Olivier et al., 2016; Peckitt & McCaig, 2019; Pontillo, Spinelli, & Sennett, 2014; Struyf et al., 2014; Sundaram, Bhargava, et al., 2012).

The gaps identified in the literature were highlighted as:

1. The lack of the usage of proper injury definitions used in studies determining the association of biomechanical factors to shoulder pain in overhead athletes and cricketers alike (Achenbach et al., 2019)
2. In the very few studies assessing cricketers the majority of the cricketers were either not defined by player role or were mainly small sample sizes and consisted only of the elite athlete population and/or the level of play was not defined and/or the definition of injury did not include time-loss injuries (Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Giles & Musa, 2008; Olivier et al., 2016; Peckitt & McCaig, 2019).
3. Endurance, proprioception and dynamic stability of the shoulder was rarely tested as part of the baseline screening procedures even though they play a role in the prevention and injury rehabilitation of shoulder pain and injury (Achenbach et al., 2019).
4. In addition to the above authors have consistently recommended that scapula dyskinesia be evaluated as a possible associated or causative factor to shoulder pain (Arora et al., 2015).

This summary of this information is displayed in the mad map below (Figure 2.6). Each of these important factors are then discussed in the information below.

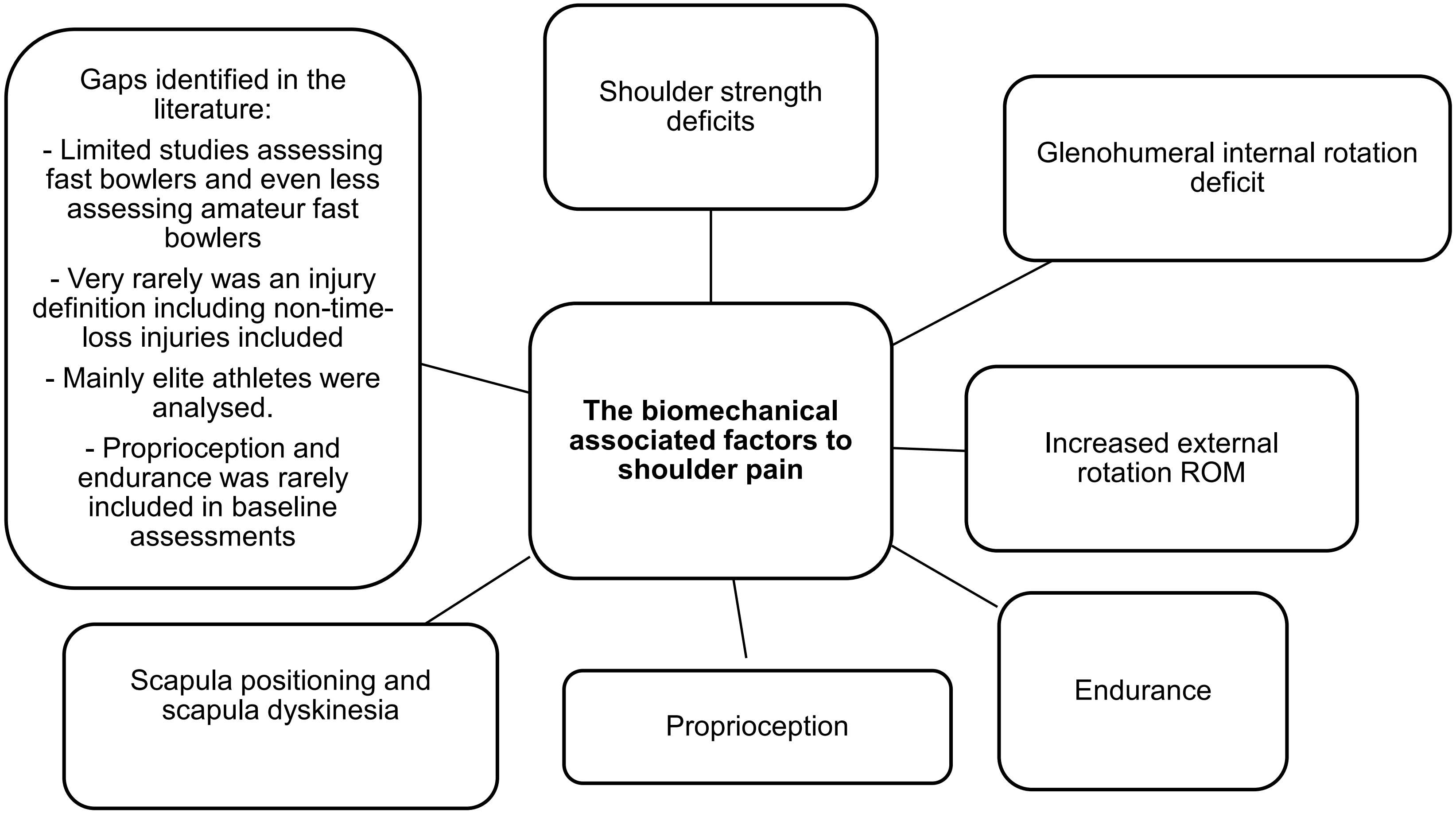


Figure 2.6: A summary of the key findings from the full text review on associated factors to shoulder pain

2.7 ENVIRONMENTAL FACTORS ASSOCIATED WITH SHOULDER PAIN

The following extrinsic (environmental factors) and/or non-modifiable factors have been shown to have been associated to shoulder pain; bowling- and training workload, age, sex, past injury and player level (Asker et al., 2018). Other factors included factors related to bowling technique and type of action (Forrest et al., 2017; Olivier & Gray, 2018). Kibler et al. (2013) determined that too many and too few off days between bowling sessions and deliveries per week was associated with increased risk of injury.

2.8 PERSONAL FACTORS ASSOCIATED TO SHOULDER PAIN

Olivier et al. (2016) investigated the extrinsic- and intrinsic factors associated with non-contact injuries in adult cricket fast bowlers via a systematic literature review. Although extrinsic- and intrinsic factors related to injury in fast bowlers were studied, the pre-disposing factors to injury such as shoulder pain (medical attention injuries where players still participate in spite of their injury) were not investigated. Intrinsic factors refer to the elements that are within the body, the structures and biomechanics behind actions and how these predispose an individual to pain and injury (Olivier et al., 2016). Understanding the cause of shoulder injury provides insight into potential causes of shoulder pain. The muscle imbalance and increased range could lead to the development of pain in the shoulder joint. However, the abovementioned study focused on time-loss injuries only and although it provides insight into injury development, they are unable to confirm the extent to which these elements precipitate pain (Olivier et al., 2016). A proposed mechanism for shoulder pain in cricketers is illustrated in Figure 2.7 (Arora et al., 2015).

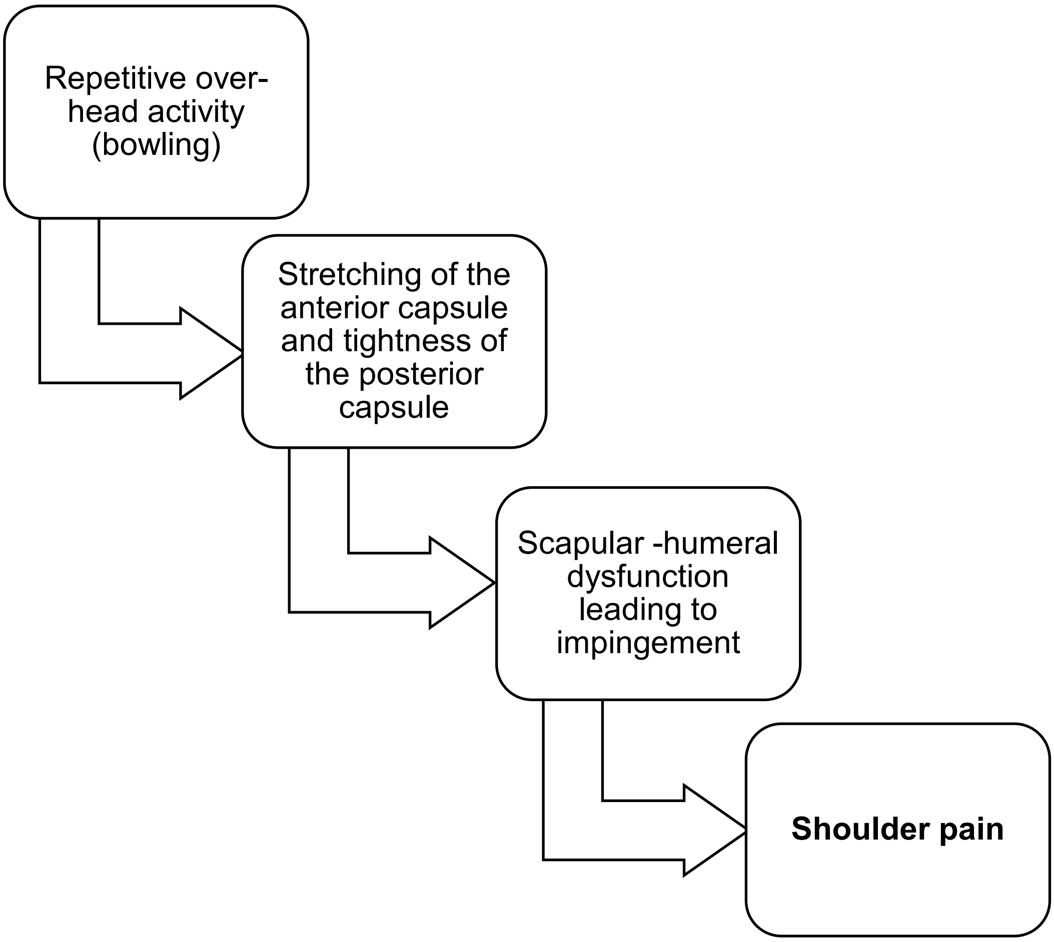


Figure 2.7: A combined mechanism for shoulder pain in fast bowlers (derived and adapted from (Arora et al., 2015)

2.9 PERSONAL FACTORS (BIOMECHANICAL INTRINSIC FACTORS) THAT ARE ASSOCIATED WITH SHOULDER PAIN IN AMATEUR FAST BOWLERS

The associated factors to shoulder pain most likely include: shoulder strength deficits, glenohumeral internal rotation deficit (GIRD), an increase in external rotation ROM, a decrease in internal ROM, fatigue, proprioception and poor scapula positioning including scapula dyskinesia (Achenbach et al., 2019; Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Asker et al., 2018; Dabholkar et al.; Ghosh & Mondal, 2016; Hickey et al., 2018; Olivier et al., 2016; Peckitt & McCaig, 2019; Pontillo et al., 2014; Struyf et al., 2014; Sundaram, Bhargava, et al., 2012). At the scapula summit, fatigue, ROM and muscle strength, proprioception and capsular pathology have been noted to be associated to the development of shoulder pain (Kibler et al., 2013).

In a longitudinal cohort study, collegiate football players were assessed for endurance proprioception, strength, endurance and scapula position from the baseline testing muscle strength and endurance deficits was found to be associated to the development of shoulder pain (Pontillo et al., 2014). A logistic regression analysis was used to determine if these factors could in turn predict shoulder pain and injury (Pontillo et al., 2014). The results obtained by Pontillo et al. (2014) did not reach statistical significance thus limiting generalisability of the results. There was, although, an indication that there is an association between decreased strength, endurance, proprioception and shoulder pain in overhead athletes (Pontillo et al., 2014).

Studies looking into the biomechanics of the shoulder joint revealed a deficit in the internal rotation strength of bowlers (Olivier, Stewart, Olorunju, & McKinon, 2015b). Shoulder rotational strength was one of the risk factors identified for the development of shoulder pain in a longitudinal cohort study assessing elite handball players (Achenbach et al., 2019). In another cross-sectional study, bowling speed and performance was also associated with the strength of the surrounding scapula muscles (Anand et al., 2017). In a study where overhead athletes were assessed for isometric muscle strength, it was found that overhead athletes without shoulder pathology (compared to those with pathological symptoms) possessed decreased strength and muscular imbalance of the scapular muscles. The findings specifically indicated that the medial rotators and protractors of the scapula had decreased strength (Cools et al., 2005).

Glenohumeral internal rotation deficit (GIRD) as well as a gain in external rotation ROM have been identified to contribute to shoulder pain/injury in overhead athletes (Giles & Musa, 2008; McClure et al., 2009; Saccol, Almeida, & de Souza, 2016). The biomechanical adaptations that result from the repetitive overhead throwing motion, alter the arc of glenohumeral rotation, resulting in increased external ROM and decreased internal rotation ROM (Giles & Musa, 2008; Sundaram, Bhargava, et al., 2012). The biomechanical adaptations will, over time, result in soft tissue changes that will predispose fast bowlers to antero-superior humeral head migration which will lead to shoulder impingement and pain; labrum tears and rotator cuff strains (Chu, Jayabalan, Kibler, & Press, 2016; Ellenbecker & Cools, 2010; Kinsella, Thomas, Huffman, & Kelly, 2014).

It was determined that increased shoulder internal- and external rotation ROM in cricketers play a role in the development of shoulder injury (Dutton et al., 2020; Giles & Musa, 2008; Olivier et al., 2020; Peckitt & McCaig, 2019; Scott-Hunter et al., 2015; Sundaram, Skn, & Karuppannan, 2012). In a cross-sectional study conducted in 2012, the internal- and external rotation ROM deficits between dominant and non-dominant arms of cricket players, as well as the differences in the ROM measurements between fast- and spin bowlers was evaluated (Sundaram, Bhargava, et al., 2012). The authors found that both spin bowlers and fast bowlers have reduced internal rotation and increased external rotation ROM in their dominant shoulders, evident in other studies mentioned (Sundaram, Bhargava, et al., 2012). Previous and current shoulder injuries or pain were excluded from the study by Sundaram, Bhargava, et al. (2012) as well as participants involved in other overhead sports. When the internal rotation ROM of a cricket player decreases to a larger extent than the gain of external rotation ROM, it results in a GIRD. Glenohumeral Internal Rotation Deficit is associated with shoulder pain and injury in overhead athletes (Clarsen, Bahr, Andersson, Munk, & Myklebust, 2014; Giles & Musa, 2008; Keller et al., 2018; Olivier & Gray, 2018; Sundaram, Bhargava, et al., 2012). It has been reported that internal rotation is significantly decreased in the dominant shoulder, as compared to the non-dominant shoulder (Clarsen et al., 2014; Giles & Musa, 2008; Keller et al., 2018; Olivier & Gray, 2018; Sundaram, Bhargava, et al., 2012) . GIRD is associated with the gradual onset of non-specific shoulder pain in elite cricketers (Sundaram, Bhargava, et al., 2012). The presence of shoulder rotational dysfunction, associated with the front-on bowling action and excessive external rotation ROM have been shown to contribute to chronic shoulder injuries in cricket fast bowlers (Sundaram, Bhargava, et al., 2012). Furthermore, studies have shown that there is a marked increase in external rotation ROM, and loss of internal rotation ROM in cricketers who experienced shoulder pain (Arora et al., 2015; Sundaram, Bhargava, et al., 2012).

In addition to the aforementioned findings, proprioception (the sense of the position of one's shoulder in space) was evaluated as a potential contributing factor to shoulder pain. It was found that a lack of proprioception at the shoulder joint increased with muscle fatigue (Weerakkody & Allen, 2017).

The lack of proprioception was determined after observing a significant drop in the isometric muscle voluntary control in the overloaded shoulder extension after bowling exercises were performed (Weerakkody & Allen, 2017). Without adequate proprioception, there is an increased risk for damage to, and pain within, the shoulder joint. The negative effects of fatigue on proprioception, bowling accuracy and the shoulder position, contribute to the cricketers experiencing shoulder pain and injury in training, or in-game situations (Weerakkody & Allen, 2017).

The rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) situated around the shoulder joint, can become affected (tears, strains and tendinopathies) due to overuse during overhead sports such as cricket as well as in the event of poor scapula positioning (Cools et al., 2008). The rotator cuff muscles keep the head of the humerus in the glenoid fossa. The shoulder joint is largely dependent of soft tissue structures (such as the rotator cuff muscles) for stability as the anatomical structure of the shoulder joint is such that it is at risk of instability. The physiological make-up of the shoulder joint also predispose it to pain, injury and pathology (Behnke, 2012). Poor scapula positioning, whether static or dynamic, may lead to impaired functioning, which in turn may result in shoulder pain/injury. Poor scapula positioning usually results from poor muscular control, joint restrictions, altered muscle length and or muscle strength imbalances (Borsa et al., 2008). Overhead athletes are athletes who perform repetitive overhead activities such as bowling or throwing. The adequate functioning of the musculature around the shoulder joint can either prevent or rehabilitate shoulder pain in overhead athletes, such as fast bowlers (Borsa et al., 2008).

Intrinsic factors that have been associated with shoulder pain were recognized in a literature study that considered the person's weight, age, gender, number of years participating in the sport, the level at which they play, the number of plays per week, GHJ ROM and scapula position (Struyf et al., 2014).

Individuals who had any of the following characteristics: male; within the age range of 20-25 years; overweight; played an overhead sport for more than five years; played at a higher level (i.e. elite); played more than four times per week; had increased internal rotation or external rotation within the shoulder joint; presented with a downwardly-rotated scapula; had less scapula upward rotation; and had winging or pseudo-winging had had an increased risk for the development of shoulder pain (Struyf et al., 2014).

In addition to the above, athletes that developed shoulder pain had significantly less upward scapular rotation at 45 degrees and 90 degrees of shoulder abduction, in comparison to athletes that were pain-free (Struyf et al., 2014). The non-dominant shoulder also had less upward rotation compared to the dominant shoulder (Struyf et al., 2014). Further research is required to understand the effect of less scapular upward rotation in 45 degrees to 90 degrees of shoulder abduction in individuals with shoulder pain and whether this is a causative factor, or is caused by the pain (Struyf et al., 2014).

According to the study by Struyf et al. (2014), that evaluated 113 individuals participating in recreational overhead sports only, 25 out of the 113 participants developed shoulder pain during the two year study period. Thirty-three participants demonstrated winging of the scapula, and 29 demonstrated pseudo-winging of the scapula on the dominant shoulder. There are some inconsistencies noted in the reported data of the study, as data was collected by use of a questionnaire as well as clinical measurement, some of the participants did not complete both sets of data collection. This study provided baseline information on the effect scapular positioning has on shoulder injuries, although it was only performed on individuals under the age of 18. The study concluded that athletes with shoulder pain presented with elements of scapular dyskinesia. It was suggested that further research to determine significant risk factors that may lead to shoulder injury is necessary (Struyf et al., 2014). Further research, to analyse the effect of scapular dyskinesia on participants engaged in overhead sports on an elite level, was also recommended (Struyf et al., 2014). Further research needs to be done on an older amateur population in order to generalise these findings to a greater population. Another study noted that the presence of scapular dyskinesia in individuals with shoulder pain was relatively high.

However, the evidence of scapular dyskinesia, as a reliable contributing factor to pain and injury is inconclusive (Kibler et al., 2013).

Scapular dyskinesia is more commonly present in fast bowlers with shoulder injury, such as rotator cuff tears and impingement syndrome when compared with non-injured shoulders (Struyf et al., 2014).The findings of scapula dyskinesia tests are described as winging, tipping, asymmetry and poor movement patterns (Struyf et al., 2014). Winging has been described as the lifting of the medial border of the scapula from the thoracic cage (or off the thorax) due to a weakened serratus anterior (Huang, Ou, Huang, & Lin, 2015). Tipping refers to the lifting of the inferior angle of the scapula off the thorax due to weakened and or poor activation of the lower fibers of the trapezius (Huang et al., 2015). Pseudo-winging refers to the lifting of the inferio-medial border of the scapula due to decreased eccentric strength of the rotator cuff.

Shoulder pain has been described as a widespread complaint in overhead athletes due to highly repetitive shoulder joint movement, the strength and strain in both static and dynamic shoulder activity (Asker et al., 2018). Cricket players experiencing pain presented with less downward scapular rotation, at 90 degrees of shoulder abduction, more cases of impingement and an increased load on the rotator cuff muscles, as compared with those who did not have shoulder pain. The study revealed a relationship between the quality of movement within the joint and the experience of pain (Struyf et al., 2014). The activity and participation of bowling and the technique related factors have been shown to be associated to shoulder pain (Crewe, Campbell, Elliott, & Alderson, 2013).

2.10 THE ACTIVITY OF BOWLING AND PARTICIPATION IN CRICKET

The fast bowler is considered as one of the most important members of a cricket team and bowling is one of the most influential factors in the outcome of a cricket match (Glazier & Wheat, 2014). The aforementioned factors lead to the development of specialised bowling academies around the world. The aim of these academies are to promote safe and effective techniques of bowling. The technique of fast bowling has been indicated as a contributing factor to shoulder pain in fast bowlers (Forrest et al., 2017; Olivier et al., 2016).

Bowling includes delivering a 156 gram ball towards a batter using an overhead activity (Ahamed et al., 2014). Fast bowling is a complex skill and is classified as fast bowling when the ball is delivered to the batter at a speed of 120-160km/h (Ahamed et al., 2014). Broadly, the bowling technique starts off with the run-up and the pre-delivery stride transitioning into the delivery stride and lastly the follow through (Glazier & Wheat, 2014). The bowling technique requires repetitive combination movements of the upper limb (Finch, Elliott, & McGrath, 1999). There are three different bowling action types in fast bowlers (Ferdinands, Kersting, Marshall, & Stuelcken, 2010). A bowling action is a set of movements performed by the bowlers to release the ball in the direction of the batter (Glazier & Wheat, 2014). The three different fast bowling action types are side-on action, front-on action and a mixed action (Ferdinands et al., 2010). The bowlers performing the mixed action have been indicated to be most susceptible to pain and injury (Ferdinands et al., 2010).

Not only are the technique-related factors identified to be contributing to pain and injury in fast bowlers, fast bowlers commonly bowl through pain and thereby decreasing performance (Ranson & Gregory, 2008). Injuries in fast bowlers limit performance and playing and/or training time (Orchard, Kountouris, et al., 2016). Shoulder strength and ROM are not only described to have been associated to shoulder pain in overhead athletes, these factors also affect performance in fast bowlers (Ghosh & Mondal, 2016).

The biomechanical factors described in sub-section 2.3.2.1 show that the anatomical makeup of the shoulder and the technique of bowling play an important role in the development of pain (Crewe et al., 2013). Stuelcken, Ferdinands, Ginn, and Sinclair (2010) determined that there is a peak in the distraction forces placed on the shoulder during the follow-through phase of bowling. These forces put strain on the shoulder joint and the surrounding structures, specifically on those muscles that are responsible for the dynamic stabilisation of the shoulder. It was found that weakness, or muscular imbalance, may allow these forces to impose damage to the integrity of the shoulder during the bowling action (Struyf et al., 2014; Stuelcken et al., 2010). This may lead to the development of pain within the shoulder.

Future studies need to assess the strength of the dynamic stabilisers of the shoulder as well as the presence of scapula dyskinesia (Stuelcken et al., 2010).

2.11 CONCLUSION

Glenohumeral internal rotation deficit as well as a gain in external rotation range have been identified to contribute to shoulder pain/injury in overhead athletes. As described, the following factors have been shown to be related to shoulder pain and/or injury in overhead athletes: internal- and external rotation shoulder ROM; muscle activation around the scapula; scapula dyskinesia; shoulder and scapula muscle strength; fatigue; and proprioception. Although further research is needed in order to determine the effect of scapular dyskinesia on participants engaged in overhead sports on an amateur level, scapula dyskinesia is frequently present in overhead athletes with shoulder pain. The measurement of shoulder internal- and external rotation ROM may serve the purpose of predicting injury although this needs to be investigated. Due to the fact that mainly time-loss injuries are reported on in elite cricketers and overhead athletes, the associated factors related to shoulder pain in amateur overhead athletes and amateur fast bowlers alike are relatively unknown. Even though fast bowlers are considered to be at the highest risk for shoulder pain and the level of play plays a role in the development of shoulder pain, the associated factors to shoulder pain in amateur fast bowlers as well as the incidence thereof is unknown.

2.12 EXERCISES TO ADDRESS THE BIOMECHANICAL FACTORS ASSOCIATED WITH SHOULDER PAIN

In subsection 2.1, the knowledge regarding the incidence and prevalence of shoulder pain in fast bowlers was described. The evidence available regarding shoulder incidence and prevalence in fast bowlers was either focussed on the elite cricketer or the adolescent elite cricketer. The definition of injury included time-loss injuries alone or focussed on joints other than the shoulder. There are no available injury incidence figures for amateur male fast bowlers in South Africa.

In subsection 2.2 the biomechanical factors associated to shoulder pain in overhead athletes was described as shoulder strength deficits; GIRD; an increase in shoulder external rotation ROM; a decrease in shoulder internal ROM; fatigue; proprioception and poor scapula positioning including scapula dyskinesia (Achenbach et al., 2019; Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Asker et al., 2018; Dabholkar et al.; Ghosh & Mondal, 2016; Hickey et al., 2018; Olivier et al., 2016; Peckitt & McCaig, 2019; Pontillo et al., 2014; Struyf et al., 2014; Sundaram, Bhargava, et al., 2012). Even though the above mentioned factors regarding shoulder pain has been described in the literature, no published information investigating the associated factors to shoulder pain in amateur fast bowlers in South Africa could be found.

Shoulder pain in the overhead athlete can be commonly attributed to sport-specific adaptations such as decreased extensibility, strength and posture in and around the GHJ and the scapula (Cools, Johansson, Borms, & Maenhout, 2015). Injury prevention exercise programmes have been described to reduce injury incidence in athletes (Forrest, Hebert, Scott, & Dempsey, 2020). In subsection 2.12 of the current literature review, the aim was to describe exercises proven to address the commonly associated biomechanical factors to shoulder pain in overhead athletes. A search strategy was not used for the third aspect of the literature review as this was conducted after the associated factors were determined and the exercises were selected according to the pre requisites of the exercise programme and their effectiveness in addressing the determined associated factors. In this subsection each biomechanical factor associated with shoulder pain (as identified through literature) will be used to justify an exercise best suited to address each biomechanical factor. The pre-requisite criteria

of each exercise included in section 2.3 was that it needed to be easily performed field-side with the no equipment usage necessary. This was due to the unavailability of specialised equipment on the field-side, only exercises where no equipment is needed were considered for inclusion.
The shoulder joints of overhead athletes have been identified as a primary site for the occurrence of injury and pain (Andersson, Bahr, Clarsen, & Myklebust, 2017; Forrest et al., 2020; Fredriksen, Cools, Bahr, & Myklebust, 2020; Pontillo et al., 2014). In order to mitigate injuries and pain, preventative measures have to be taken. Asker et al. (2018) indicated that the prescription of exercises are effective means of preventing injury and subsequently, pain.

The American College of Sports The American College of Sports Medicine (2017) described the principles of exercise prescription and an exercise session as:

- Warm-up: This includes five to ten minutes of light-to-moderate intensity cardiorespiratory and muscular endurance activities.
- Conditioning: this would consist of at least 20 to 60 minutes of sport specific activity. Exercise can be done in bouts (like a cricket match) as long as the cumulative time of the bouts is 20 to 60 minutes.
- Cool-down: According to the guidelines this would consist of at least five to ten minutes of light intensity cardiorespiratory and muscle endurance activities.
- Stretching: Guidelines indicate that 10 minutes of stretching exercises can either be performed after the warm-up or cool-down period

Cools et al. (2015) found that shoulder injuries can be minimised by addressing the following four risk factors in an injury prevention programme: GIRD; eccentric strength of the shoulder external rotator muscles; scapula dyskinesia; and strength in and around the scapula and shoulder joint. A scientific basis for the prevention of injury in overhead athletes was created (Cools et al., 2015). The main goals of a shoulder prevention exercise programme should be to restore flexibility to the scapula soft tissue surrounds (pectoralis minor, length of the lateral rotators, the posterior capsule and other posterior shoulder structures) and to increase scapula muscle performance, coordination, strength and control (Cools et al., 2015).

Dynamic stabilisers control movement eccentrically (Comerford & Mottram, 2001). One example of this would be the poor endurance of serratus anterior resulting in scapula winging.

Global mobiliser muscles (as described in sub section 2.3.2) can lose extensibility and shorten (Comerford & Mottram, 2001). One example of this would be loss of extensibility of the lateral rotators resulting in GIRD. The contribution of GIRD to shoulder pain has been underestimated and further investigation is needed in order to accurately describe the role of GIRD in the development of shoulder pain in fast bowlers (Giles & Musa, 2008). Tightness of the posterior capsule and/or decreased extensibility of the external rotators of the GHJ has been noted to decrease internal rotation of the GHJ (Cools et al., 2015). One exercise that can be performed field-side is the sleeper stretch, as it does not require equipment to be performed effectively. The sleeper stretch has been proven effective in successfully increasing GHJ internal rotation and can also accelerate the recovery of GHJ internal rotation ROM by decreasing the permanent effects of overhead activity (Ellenbecker & Cools, 2010; Reuther, Larsen, Kuhn, Kelly IV, & Thomas, 2016). In a randomised control trial, 24 baseball players with limited ROM were subjected to the sleeper stretch for 30 seconds a day, for four weeks. The results indicated that shoulder internal rotation and infraspinatus length was significantly increased when compared to the control group after the four week intervention (Balci, Alptekin, & Alkan, 2019).

The rotator cuff muscles exhibit specific sports related adaptations leading to a decrease in the eccentric strength of the lateral rotators. Recently, focus has been shifted from isometric- or concentric strengthening of the rotator cuff to eccentric strengthening in both the rehabilitation and prevention of shoulder pain in athletes (Cools et al., 2015). Increased external rotation with a protracted shoulder would lead to pain and impingement in an overhead athletes' shoulder (Keller et al., 2018). Pectoralis minor, when shortened, results in rounded shoulders and protracted scapulae. The unilateral corner stretch or more commonly known (in layman's terms) as the wall stretch has been shown to be effective in the lengthening of the pectoralis minor muscle. The unilateral corner stretch has been described as being effective in maintaining and increasing ROM in the shoulder joint (Gutiérrez-Espinoza et al., 2019). This stretch was proven to be statistically significant in increasing the length of pectoralis minor in participants (Gutiérrez-Espinoza et al., 2019). Static stretches such as the unilateral corner stretch and the sleeper stretch need to be performed as a 30 second hold in order to be effective (Balci et al., 2019).

Decreased endurance, proprioception and dynamic stability of the scapula muscles has been related to the development of shoulder pain and injury in overhead athletes (Cools et al., 2008; Cools et al., 2007; Cools et al., 2015; Dabholkar et al.; Struyf et al., 2014). Eccentric exercises for the rotator cuff, exercises activating the lower fibres of trapezius in prone and protraction exercises were recommended in the rehabilitation of scapula dyskinesia and shoulder pain (Cools et al., 2007).

Excessive downward rotation or decreased upward rotation of the scapula has been associated with the development of shoulder pain in cricketers (Arora et al., 2015). Decreased upward rotation and winging of the scapula were both associated to the development of shoulder pain in overhead athletes (Struyf et al., 2014). Winging is primarily caused by the poor endurance and activation of the serratus anterior. Tipping or decreased upward rotation of the scapula is due to poor endurance and activation of the lower fibres of trapezius (Contemori, Panichi, & Biscarini, 2019). Andersson et al. (2017) indicated that conscious correction of the scapula orientation in exercises increases lower fibre of trapezius activation. One exercise proven to activate the fibres of lower trapezius is the prone-Y exercise or more accurately known as the prone scaption above 90 degrees in external rotation exercise (Ronai, 2016). This exercise does not only strengthen the lower fibres of trapezius, but also the posterior muscles of the shoulder-girdle (Ronai, 2016). The prone-Y exercise also can be used with or without external resistance. Therefore, the prone-Y works well field-side without the use of any equipment and would be ideal for a shoulder pain prevention programme (Ronai, 2016). Winging on the other hand is primarily caused by weak scapula protractors i.e. the serratus anterior (Contemori et al., 2019). The scapula wall slide is an exercise developed to retrain dynamic stability, strength and endurance of the GHJ (Hardwick, Beebe, McDonnell, & Lang, 2006). The scapula wall slide was compared, regarding its activation of serratus anterior, to other traditional exercises and was found favourable in injury treatment prevention in overhead athletes {Hardwick, 2006 #152}. This was mainly due to the fact that serratus anterior would be activated using the wall slide in an overhead position which is needed in bowling (Hardwick et al., 2006). Similar to the prone-Y exercise, another benefit of the scapula wall slide is that it requires no equipment and can easily be performed field-side.

Delayed muscle recruitment and timing of the middle- and lower fibres of the trapezius muscle have been identified in athletes with shoulder pain (De Mey, Cagnie, Van De Velde, Danneels, & Cools, 2009). In a controlled laboratory study, the timing of the different fibres of the trapezius muscle in relation to the deltoid muscle was evaluated. The authors found that the prone horizontal extension exercise promoted early activation of the middle- and lower fibres of trapezius (De Mey et al., 2009). This exercise is recommended for the treatment of timing disorders of the trapezius muscle. Timing disorders of the middle- and (more importantly) the lower fibres of trapezius have been shown to predispose overhead athletes to shoulder pain. Therefore, the prone horizontal exercises are justified for inclusion in shoulder prevention programmes in overhead athletes such as fast bowlers (De Mey et al., 2009).

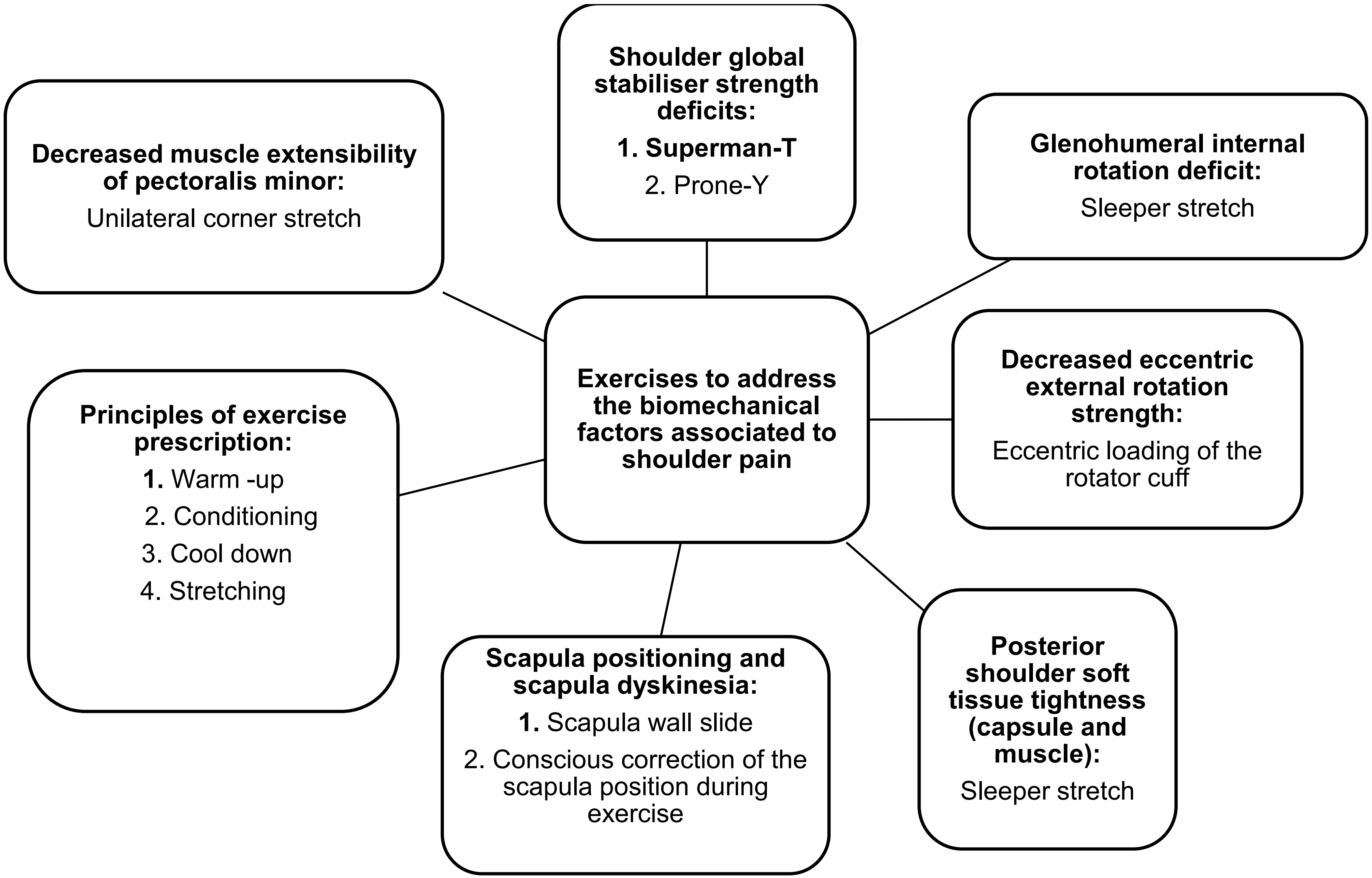


Figure 2.8: Exercises addressing the biomechanical factors associated to shoulder pain

2.13 CONCLUSION

Although none of these exercises have been tested to prevent shoulder pain in overhead athletes they have been described as effective in addressing the biomechanical factors associated to shoulder pain. In subsection 2.3 the incidence of shoulder pain in amateur fast bowlers was described as being relatively unknown although, the incidence of shoulder pain recorded in elite fast bowlers is significant. The incidence of shoulder pain in a study assessing amateur fast bowlers including both time-loss and non-time-loss shoulder injuries would be expectedly higher than in elite fast bowlers alone. This highlighted the necessity of investigating the true incidence of shoulder pain in fast bowlers.

In order to develop a preventative or rehabilitative exercise programme addressing shoulder pain in amateur fast bowlers, firstly the incidence of shoulder pain needs to be determined. There are large differences in both the injury incidence and the associated factors to shoulder pain in the different roles and levels of cricketers i.e. amateur fast bowlers vs elite fast bowlers vs cricketers performing other player roles that fast bowling and playing at elite, professional and recreational levels.

Secondly it would be necessary to determine the biomechanical factors associated to shoulder pain in amateur fast bowlers. The biomechanical modifiable factors possibly associated to shoulder pain are described in section 2.6 above. Once these modifiable biomechanical associated factors to shoulder pain are determined possible shoulder pain prevention strategies could be initiated such as exercise prevention programmes. Section 2.12, Figure 2.8 summarizes the exercises most suited to the prevention of shoulder pain in overhead athletes. The unilateral corner stretch (addressing pectoralis minor length), the sleeper stretch (addressing the length and the tightness of the posterior structures of the shoulder), the scapula wall slide, the prone-Y and superman-T exercises, eccentric loading of the rotator cuff and conscious correction of the scapula positioning (addressing the muscle strength, proprioception and endurance of the surrounding scapula muscles) have all been described as exercises addressing the factors possibly associated to shoulder pain. Even though the incidence of shoulder pain is significant in fast bowlers there are no scientifically proven exercise programmes designed and /or available to prevent shoulder pain in fast bowlers.

CHAPTER 3: STUDY 1 THE INCIDENCE OF, AND THE ASSOCIATED FACTORS TO SHOULDER PAIN IN AMATEUR FAST BOWLERS

3.1 INTRODUCTION

Cricketers are at a lower risk for sustaining injuries than most athletes, although, shoulder injuries are frequent in cricketers, especially in fast bowlers (Forrest et al., 2017; Olivier et al., 2016; Ranson & Gregory, 2008). Injuries sustained during the cricket season may limit players' performance as well as playing- and or training time (Orchard et al., 2015). Shoulder injuries in cricket players make up approximately five percent (5%) of all the injuries cricket players experience (Arora et al., 2015). The estimation of 5% is most likely an underestimation, due to the fact that in most instances only time-loss injuries were reported on (Arora et al., 2015). The suspected underestimation of injury prevalence occurred until a consensus statement was released in 2016 (Orchard, Ranson, et al., 2016). In addition to the limited reporting up until 2016, non-time-loss shoulder injuries were also omitted from incidence statistics. The inaccurate and underreporting of injury incidence data resulted in underestimated incidence of shoulder injuries in fast bowlers.(Orchard et al., 2015).

Cricketers have different playing roles i.e. bowlers, batters, wicketkeepers and all-rounders. All cricketers throw but bowlers are most at risk of developing shoulder pain, as their player-role requires the most amount of overhead activity (i.e. the action associated with bowling) (Arora et al., 2015). According to the available literature, the causes of shoulder pain in overhead athletes include: shoulder strength deficits, glenohumeral internal rotation deficit (GIRD), an increase in shoulder external rotation ROM, a decrease in shoulder internal rotation range of motion, fatigue, poor proprioception and poor scapula positioning including scapula dyskinesia (Achenbach et al., 2019; Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Asker et al., 2018; Dabholkar et al.;

Ghosh & Mondal, 2016; Hickey et al., 2018; Olivier et al., 2016; Peckitt & McCaig, 2019; Pontillo et al., 2014; Struyf et al., 2014; Sundaram, Bhargava, et al., 2012).

Glenohumeral internal rotation deficit (GIRD) has been identified to contribute to shoulder pain/injury in overhead athletes (Giles & Musa, 2008; McClure et al., 2009; Saccol et al., 2016). A gain in external rotation range of motion (ROM) in combination with a shortened pectoralis minor could lead to adaptations of the rotator cuff such as eccentric weakness and this has been identified to contribute to shoulder pain/injury in overhead athletes (Giles & Musa, 2008; McClure et al., 2009; Saccol et al., 2016). The biomechanical adaptations resulting from repetitive bowling (overhead activity) may alter the ROM of the arc of glenohumeral rotation, resulting in eccentric weakness of the rotator cuff and increased external rotation ROM (Chu et al., 2016; Ellenbecker & Cools, 2010; Giles & Musa, 2008; Kinsella et al., 2014; Sundaram, Bhargava, et al., 2012). Decreased internal rotation ROM (commonly referred to as GIRD) also presents in bowlers and results in posterior capsular- and soft tissue tightness predisposing fast bowlers to humeral head migration which can lead to impingement and shoulder pain (Chu et al., 2016; Ellenbecker & Cools, 2010; Giles & Musa, 2008; Kinsella et al., 2014; Sundaram, Bhargava, et al., 2012).

In the South African province of Gauteng, within the Northern Cricket Union Premier Cricket League, it has been noted by the primary researcher who has played at this level of cricket for numerous years that the players, especially the fast bowlers, suffer from shoulder pain and -injury. Due to the fact that mainly time-loss injuries were reported on until 2016, the incidence of shoulder pain may be grossly underestimated in fast bowlers. The incidence studies after the year 2016 are mainly focussed on cricketers in general or elite fast bowlers. The incidence of shoulder pain in amateur fast bowlers is unknown. The associated factors to shoulder pain in amateur fast bowlers (such as premier league fast bowlers) has also not been studied extensively.

There are 12 teams in the Northern Cricket Union Premier Cricket League (PCL) and each of these teams consist of four to seven fast bowlers.
The Northern Cricket Union Premier Cricket League is the highest level of amateur cricket played in the Gauteng Province. The Northern Cricket Union Premier Cricket League is also the platform from which many professional/elite cricketers are selected. The training regimens are inconsistent amongst teams in the Northern Cricket Union Premier Cricket League.

The majority of cricketers have highly individualised training programmes as the individual responsibilities and or roles vary between cricketers. Therefore, each cricketer needs to be examined and evaluated as an individual. At an amateur level, such as the premier league, most cricket teams do not have a medical team on staff. They also do no possess any online logging system to keep track of injuries. These amateur fast bowlers also do not, unlike elite cricketers, play cricket exclusively or as their occupation.

Injury, including shoulder pain, is common among athletes performing repetitive overhead activities, such as amateur fast bowlers. Training load, type of training, training intensity and demographic factors are thought to predispose athletes who consistently perform overhead activities to shoulder pain (Arora et al., 2015). Scapula dyskinesia is prevalent in overhead athletes with shoulder pain, resulting in poor performance and loss of playing- and training time. At the time of conduction of the study, there was no published research available regarding the incidence of shoulder pain or the associated factors thereof in amateur fast bowlers. As indicated above and discussed in the literature (Chapter 2: Figures 2.4 and 2.5), the evidence available regarding shoulder incidence and prevalence in fast bowlers either focussed on the elite cricketer, or the adolescent elite cricketer, or time-loss injuries alone, or other joints (which do not include the shoulder joint).

The biomechanical factors associated to shoulder pain in overhead athletes was described as shoulder strength deficits, GIRD, an increase in shoulder external rotation ROM, a decrease in shoulder internal ROM, fatigue, proprioception and poor scapula positioning including scapula dyskinesia (Achenbach et al., 2019; Aginsky et al., 2004; Anand et al., 2017; Arora et al., 2015; Asker et al., 2018; Dabholkar et al.; Ghosh & Mondal, 2016; Hickey et al., 2018; Olivier et al., 2016; Peckitt & McCaig, 2019; Pontillo et al., 2014; Struyf et al., 2014; Sundaram, Bhargava, et al., 2012). There are no available injury incidence figures for amateur male fast bowlers in South Africa. There is also no information available regarding the associated factors to shoulder pain in amateur fast bowlers.

The first aim of study one was to determine the incidence of shoulder pain in Northern Cricket Union Premier Cricket League fast bowlers. The second aim of study one was to determine the most commonly associated biomechanical factors to shoulder pain in Northern Cricket Union Premier Cricket League fast bowlers. Therefore, the objectives of the current study were to determine the incidence of shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League, to determine the presence of scapula dyskinesia in this population and determine the most commonly associated biomechanical factors to shoulder pain in amateur fast bowlers from the Northern Cricket Union Premier Cricket League.

3.2 METHODOLOGY

3.2.1 Study Design and Setting

A prospective, longitudinal cohort study design was followed in the execution of the study. The study design was selected as it is appropriate for identifying particular exposures over time; establishing a sequence of events; and excluding recall bias in all participants (Caruana, Roman, Hernández-Sánchez, & Solli, 2015).

3.2.2 Study Setting

In South Africa, the Northern Cricket Union Premier Cricket League consists of 12 amateur cricket teams in the Northern Gauteng area. All 12 of these amateur teams were contacted and invited to participate in the current study. Data was collected at the club houses of the respective cricket clubs.

3.2.3 Participant Recruitment

Cricket South Africa and the Northern Cricket Union were approached prior to the commencement of the study. Permission was obtained to recruit fast bowlers for study one. Permission was granted by both of the cricketing authorities governing the fast bowlers needed to accomplish the aims of study one (Appendix: A). The captains and management staff were then sent out an email by the governing authorities to recruit fast bowlers. The agreeing club captains and management was then contacted for consent. The study population consisted of volunteering fast bowlers at the age of 18 or above who were currently selected for any of the twelve premier league cricket teams.

3.2.4 Study Population and Sampling

The study population size was estimated to be approximately 72 fast bowlers in the Northern Cricket Union Premier Cricket League. The study intended to assess

11 parameters including ROM tests, strength tests, biomechanical tests, stability tests and endurance tests.

At most, six of the eleven parameters were set to be entered into the prediction equation. By the convention to indicate 10-15 Northern Cricket Union Premier Cricket League FB per parameter into this study, i.e., 60 to 70 Northern Cricket Union Premier Cricket League fast bowlers would have sufficed. Therefore, the study sample of 72 participants would have sufficed in order to develop prediction equations, however only 44 fast bowlers consented to participate in the current study resulting in an adaption of the data analysis. Therefore, the statistics were adapted accordingly and described under the data analysis sub-section (Subsection 3.8).

3.2.4.1 Inclusion Criteria

The players were recruited through the Northern Cricket Union Premier Cricket League on a voluntary basis. The inclusion criterion was: PLFB, 18 years or older, who were injury free and played at the premier league level of club cricket in the Northern Gauteng region at the time of the conduction of the study.

3.4.4.2 Exclusion Criteria

Players were excluded if they; were excluded from selection to the team due to an injury; and/or have undergone any surgery to the shoulder; and/or present with any progressive musculoskeletal disease.

3.4.7 Instrumentation and Outcome Measures

Multiple outcomes measures were used in the execution of the study, to ensure that all possible biomechanical factors that could potentially be associated with shoulder pain in fast bowlers are tested. A summary of the outcomes measures is illustrated in Figure 3.3.

ROM measurement

The Hitech Therapy™ ten-inch goniometer (Figure 3.1) was used to measure shoulder internal and external ROM. The ten-inch goniometer has been reported to have an intra-tester correlation coefficient of 0.98 and is therefore a reliable measurement tool for shoulder rotational measurements (Kolber & Hanney, 2012; Riddle, Rothstein, & Lamb, 1987).

Figure 3.1: Photograph of the Hitech Therapy™ ten-inch goniometer

Isometric strength testing

Isometric strength was assessed using a handheld dynamometer (Figure 3.2) (Hoggan Micro Fet®). The dynamometer was calibrated and set to measure the force applied by the fast bowler in kilograms (kg). The handheld dynamometer has been proven reliable in the measurement of isometric strength (0.85 – 0.99) (Clarsen et al., 2014).

Figure 3.2: Hoggan Micro Fet® handheld dynamometer

Shoulder biomechanics and scapula dyskinesia

Specific tests applicable to shoulder pain and scapula dyskinesia were employed at the baseline testing session. (Refer to Table 3.1: for reliability and validity values).

Table 3.1 Reliability and validity of the outcomes measures used.

Test	**Reliability and Validity**
Scapula Dyskinesia Test (SDT)	This method has been shown to be reliable and valid among assessors to assess scapula dyskinesia and has been proven to have clinical usage capabilities. It has shown a 75 to 82 % agreement with a weighted Kappa value ranging between 0.48 to 0.61) (McClure et al., 2009).
The closed kinetic upper extremity stability test (CKUEST)	The CKCUES test is performed from a push-up position. The CKCUES Test showed excellent intersession reliability (Tucci, Martins, de Carvalho Sposito, Camarini, & de Oliveira, 2014) Reliability values, for athletic males, are as follows (Tucci et al., 2014): Number of touches: Excellent test-retest reliability (ICC=0.89) Power: Excellent test-retest reliability (ICC= 0.84) Normalized score: Excellent test-retest reliability (ICC= 0.90)

Fatigue testing by means of the Borg scale (FTBS).	The Borg scale has been proven reliable to assess the rate of exertion ICC = 0.75-0.82 (Pfeiffer, Pivarnik, Womack, Reeves, & Malina, 2002).
Isometric strength testing (IST) using a handheld dynamometer.	Isometric strength testing (IST) has displayed excellent reliability in assessing the strength of the upper limb muscles (ICC 0.85-0..99) (Agre et al., 1987).
Glenohumeral internal rotation (IR) and external rotation (ER)	The goniometer has excellent intra-rater reliability (ICC 0.94 to 0.95)

Questionnaires

The questionnaires used in this study were adopted from a previous study (Olivier, Stewart, Olorunju, & McKinon, 2015a). One questionnaire was used at the baseline testing session acquiring demographic and injury data.

The second questionnaire was administered weekly determining injury prevalence (Appendix: B). The validation and testing of the questionnaires are described in sub-section 3.6.2.

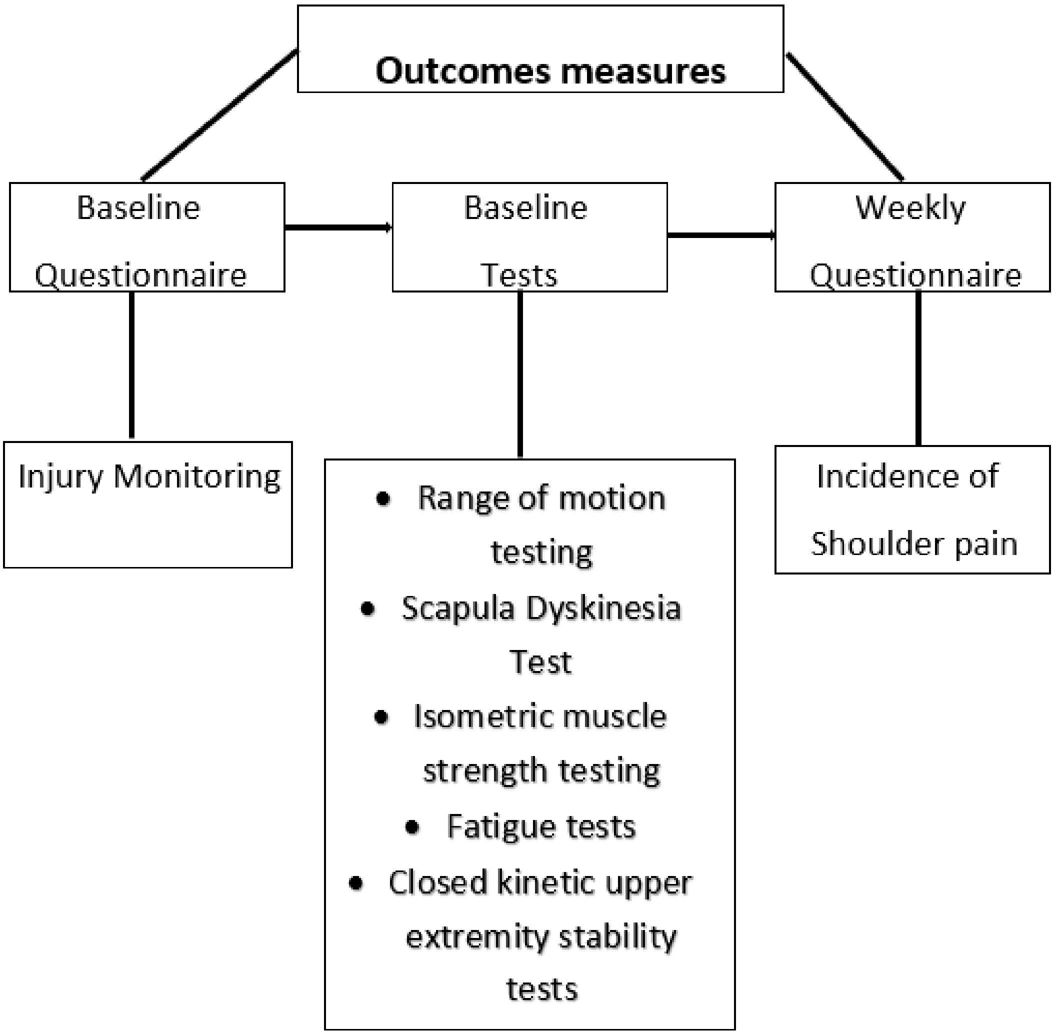


Figure 3.3: Outcome measures used in the study

3.3 ETHICAL AND LEGAL CONSIDERATIONS STUDY ONE

Prior to the conduction of Study 1, ethical and legal pre-requisites were accounted for as Physiotherapy Department, Faculty of Health Sciences and Human Research Ethics Committee (Medical) approval (Appendix: C) was obtained (number: M180410).

A patient information sheet was also given to each participant (Appendix: D). If willing to participate, each amateur fast bowler signed an informed consent form

(Appendix: E), prior to the onset of the current study. All important facts regarding the procedures and what would be expected from the amateur fast bowlers regarding the evaluation and rehabilitation programme were explained and provided in writing, before consent was obtained (Appendix: D). The expectations of the amateur fast bowler and the process of the study was explained in layman's terms to ensure that all the cricketers would know exactly what was expected from them.

The Research Electronic Data Capture (REDCap) data capturing system that was used generated unique numbers for each participant to ensure anonymity. Any personal or identifying information was removed from all forms of dissemination of the data. The data will be stored on password protected laptop for at least fifteen years. All members of the sample were given the opportunity to not participate or leave the study at any point, without prejudice.

The participating amateur fast bowlers were all given ample opportunity for questions at the pre-testing session as well given the primary researchers contact details thereby exercising the principle of autonomy. All minors were excluded from the study.

3.4 PREPARATORY PROCEDURES

Data collection was split into two parts namely; the preparatory procedures and the data collection process.

3.4.1 Pilot Study

A pilot study was conducted with the aim of recreating the data collection procedure for the main study, in terms of the logistical arrangements, timing of the procedures and training the research assistants and recreating the data collection procedure for study one. During this pilot study the research assistants were trained on the execution of the baseline testing procedure of the current study. The pilot study included seven recreational cricketers, who did not form part of the main data collection procedures.

The pilot study participants adhered to the inclusion and exclusion criteria of the current study, except for the level of play. The primary researcher applied the study methodology to the seven cricketers and worked out logistics and timed the procedures. The pilot study enabled the primary researcher to streamline the data collection procedures and timing of the baseline measurements Timing was especially important to the allocation of adequate rest time (1:3 work: rest ratio) between the endurance and strength testing procedures.

3.4.2 Questionnaire Validation

The questionnaire was sent to three physiotherapists in the field of sports medicine to establish face-validity. The team who conducted the validity testing consisted of: a professor in physiotherapy, whose key research area is physiotherapy in cricket; a physiotherapist with a PhD in movement analysis; and a practicing physiotherapist who worked with injuries in cricketers. The comments made by the physiotherapists were addressed by the adaptation of the questionnaire.

3.4.3 Research Assistant Training

A familiarisation session took place during which the research team met at a Health Sciences University Physiotherapy Department Gymnasium. This session only involved the research assistants and not the fast bowlers. All information regarding the questionnaire, as well as information regarding the study and the planning of logistics, were discussed in the session.

The principal researcher demonstrated the outcomes measures to be executed, as was established during the pilot study, and held a practice session which all the members of the research team attended. Qualified physiotherapists acted as research assistants. The research assistants were trained in terms of all the testing procedures. A demonstration was required to be done by each research assistant. Any discrepancies found between research assistants were discussed and clarified in order to maintain validity, quality control and reliability of the data collection procedure.

3.4.4 Participant Recruitment

After Cricket South Africa and the Northern Cricket Union contacted the twelve premier league cricket clubs regarding the study, the Northern Cricket Union sent the primary researcher a list of the email addresses and contact details of each of the captains and team coaches of the 12 premier league cricket clubs. The researcher then held a telephonic meeting with each of the 12 Premier Cricket League teams' captains and the coach in order to: recruit fast bowlers for the study; explain the details regarding the study; and to arrange a date and time for the baseline testing sessions.

3.5 BASELINE TESTING PROCEDURES

Each of the consenting clubs arranged a time and date for the baseline testing sessions with the primary researcher. The baseline testing sessions took place prior to the relevant practice sessions of each of the premier league clubs. During these sessions the relevant information and informed consent (Appendix: E) was explained. The aims, objectives and procedures were all described to each of the volunteering fast bowlers and their respective coaches and captains. The responsibilities and details regarding the study was clearly outlined in the consent form and the participant information sheet which was handed out to and signed by all volunteering fast bowlers (Appendix: D). All the contact details and participant email addresses for the online questionnaires were collected. Each participant was afforded time to ask any questions. If consent was obtained and the fast bowler met the inclusion criteria they proceeded to complete the baseline questionnaire and baseline testing.

3.5.1 Baseline Questionnaire

One questionnaire at the baseline testing session (paper based) and one online questionnaire (through the RedCap online platform) was used (Harris et al., 2009).

The first of the two questionnaires was the baseline injury questionnaire capturing all demographic and anthropometric data which was needed to determine incidence of, as well as predisposing factors to, shoulder pain in Northern Cricket Union Premier Cricket League FB (Appendix: B). Forty-four amateur fast bowlers consented to participate in the study and 39 of these amateur fast bowlers completed the online standardised questionnaire through REDCap.

3.5.2 Baseline Screening Tests

A standardised musculoskeletal screening procedure (Figure 3.3) at the start of the 2018/19 Premier Cricket League season was executed. All screening tests were completed within a three-week period prior to the start of the season. The primary researcher and the same five research assistants performed the tests in the same order to ensure that tests are performed in a standardised manner and order. The screening consisted of testing: shoulder internal rotation (IR) and external rotation (ER) ROM at 90° shoulder abduction; weighted and non-weight SDT; isometric strength by a handheld dynamometer for shoulder ER and IR at 90° of abduction; protraction of the scapula with the arm at 90° of forward flexion in supine; abduction in sitting at 45°; fatigue testing in two positions (scaption and prone-Y); and the CKUEST.

<u>Internal- and external rotation range of motion</u>

The passive ROM of glenohumeral IR and ER was measured in side lying (Figure 3.4) (Kolber & Hanney, 2012). Each fast bowler was positioned in side-lying on a plinth. The arm of each amateur fast bowler being tested, was placed in abduction and horizontal flexion with the weight of the torso of the fast bowler maintaining the alignment of the humerus whilst rotation was measured. The centre point of the goniometer was the olecranon process of the elbow. The stationary arm was placed parallel to the humerus and the moveable arm was placed parallel to forearm, pointed toward the styloid process of the wrist. The participant was instructed to actively externally rotate the GHJ at which point active ER of the GHJ was measured. The physiotherapist then applied overpressure at which point the passive ER was measured.

This procedure was then followed for IR of the GHJ. The total arc rotational range of motion was calculated for each shoulder by adding the IR and ER values (Wilk et al., 2011).

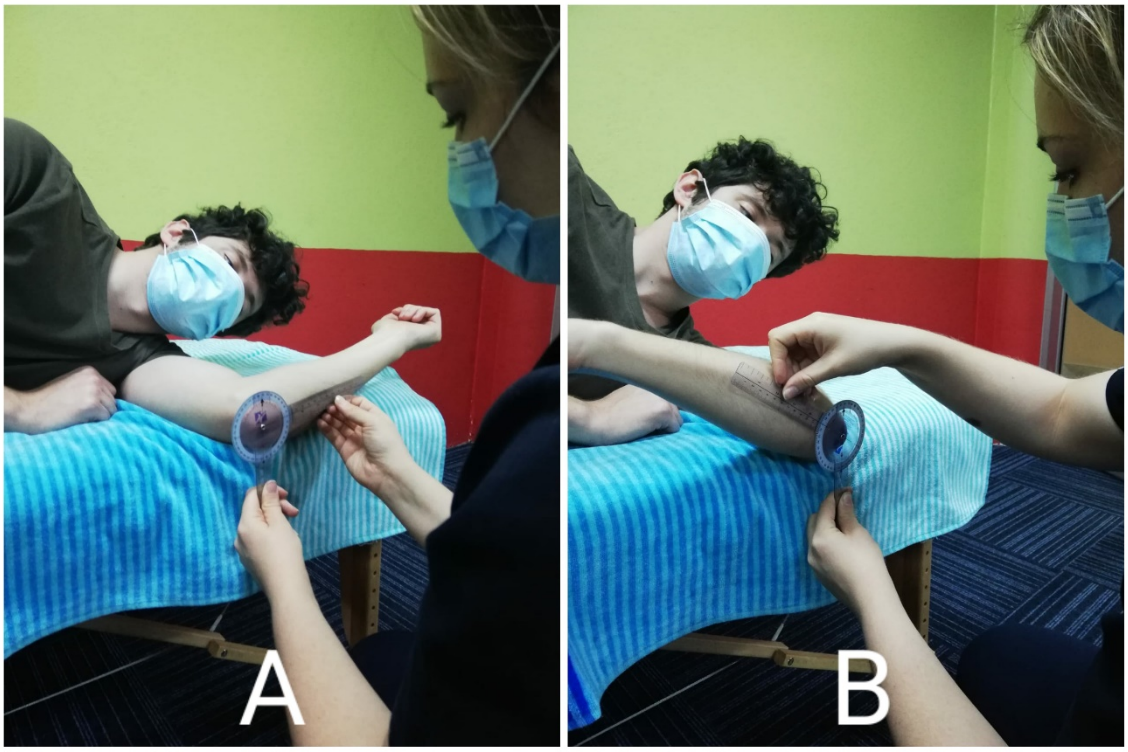


Figure 3.4: Passive shoulder IR & ER measurements A: ER ROM measurement, B: IR ROM

<u>Scapula dyskinesia test (SDT)</u>

The SDT is the clinical observation of the inferior and medial borders of the scapula for winging (medial border prominence); which has been described as lacking smooth coordinated movement and poor scapula humeral rhythm (McClure et al., 2009). The motion was observed by the physiotherapist and described as 'abnormal' (presence of deviation or dysrhythmia or /asymmetry bilaterally) or 'normal' (no presence of deviation or dysrhythmia or /asymmetry bilaterally).

Procedure: The participant stood with his back towards the physiotherapist. The participant was instructed to perform bilateral abduction and then flexion of his shoulder. This was performed five times slowly with controlled movement (a count of four breaths) downwards. The movement was repeated with a three kilogram weight in order to assess the degree of scapula dyskinesia when proprioceptive input (the three kg weight) was added.

The physiotherapist observed the motion and described it according to the procedure described by McClure and his colleagues in 2009 (McClure et al., 2009) (for both flexion and abduction). The presence of dyskinesia was described (for both flexion and abduction):

Normal motion was described as no evidence of abnormality. Subtle abnormality was when mild or questionable evidence of abnormality was present and/or not consistently present. Obvious abnormality was noted when an obvious abnormality was indicated on three or more of five trials. The final outcome was based on combined flexion and abduction movements (McClure et al., 2009).

<u>Isometric strength testing</u>

Isometric strength was assessed using a handheld dynamometer (Hoggan Micro Fet®). Isometric strength testing was performed in four positions with the participants sustaining a maximum contraction for a period of five seconds (Figure 3.5). Three trials for each position were collected and an average value was calculated, with a minimum of 30-second rest between trials as 30 seconds allows for a work: rest ratio of at least 1:3 which has been shown to be an adequate amount of time needed for recovery between isometric muscle testing sessions (Blazquez, Warren, O'Hanlon, & Silvestri, 2013).

Strength of the internal rotator muscles (Figure 3.5: A) was measured in supine with the elbow flexed at 90 degrees and the GHJ abducted at 90 degrees. The physiotherapist strapped the dynamometer to his/her palm and placed the dynamometer one centimetre below the palmar aspect of the wrist of each participant. The participant was instructed to internally rotate his GHJ with as much force as possible for five seconds whilst keeping his humerus flat against the floor ensuring poor internal rotation.

The dynamometer recorded the point of the most force produced during IR. Strength of the external rotator muscles (Figure 3.5: B) was measured in supine with the elbow flexed at 90 degrees and the GHJ abducted at 90 degrees. The physiotherapist strapped the dynamometer to his/her palm and placed the dynamometer one centimetre below the dorsal aspect of the wrist of each participant. The participant was instructed to externally rotate his GHJ with as much force as possible for five seconds while keeping his humerus flat against the floor ensuring poor external rotation (ER). The dynamometer recorded the point of the most force produced during ER. Strength of the GHJ abductors (Figure 3.5: C) was measured in sitting with the elbow flexed at 90 degrees and the GHJ abducted at 45 degrees. The physiotherapist strapped the dynamometer to his/her palm and placed the dynamometer one centimetre below the deltoid insertion of each participant. The participant was instructed to abduct his GHJ with as much force as possible for five seconds whilst keeping his humerus perpendicular to his torso ensuring poor abduction of the GHJ. The dynamometer recorded the point of the most force produced during GHJ abduction. Lastly the strength of the scapula protractors (Figure 3.5: D) was measured in supine with the GHJ flexed at 90 degrees, the elbow in full extension and the scapula protracted halfway, with the palm of the participant against the dynamometer. The physiotherapist strapped the dynamometer to his/her palm and placed the dynamometer on the centre of the palm of the participant. The participant was instructed to push with as much force as possible against the dynamometer for five seconds whilst keeping his humerus perpendicular to the floor in order to ensure consistency between tests. The dynamometer recorded the point of the most force produced during scapula protraction.

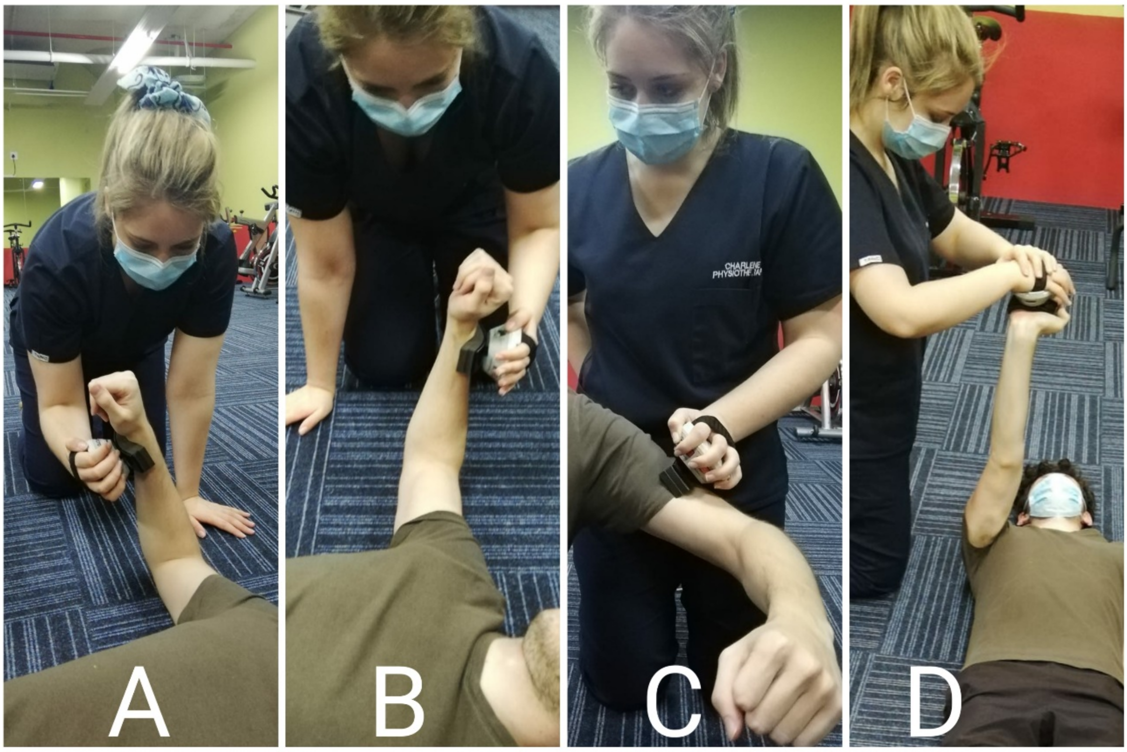


Figure 3.5: Isometric strength testing of the shoulder A: Internal rotation isometric strength testing, B: External rotation isometric strength testing, C: Abduction isometric strength testing, D: Protraction isometric strength testing

<u>Fatigue testing</u>

Muscle fatigue testing was conducted in two positions: the prone-Y position and in the scaption position. The prone-Y position and test was used to assess the endurance of the lower- and middle trapezius muscles. The decreased endurance and strength of the upper- and middle trapezius muscles have been proven to be associated to shoulder pain in overhead athletes (Struyf et al., 2014). The scaption test position was used to assess the endurance of the dynamic stabilisers around the GHJ namely; the rotator cuff and the lower trapezius as well as the endurance of the mobilising deltoid.

Each participant performed the above mentioned movements with three and 5% body weight resistance levels respectively (Clarsen et al., 2014). Although each test was conducted to fatigue the above mentioned shoulder muscles, overall fatigue levels were monitored by use of the Borg scale. The Borg scale allowed the researcher to maintain consistency regarding fatigue among the participants. The Borg scale rates the level of perceived exertion on a scale from 6 to 20 (Borg, 1982). The participants were asked to stop when the exertion reached a point of 17 to 18 (very hard) on the Borg scale (Borg, 1982). It has been found that a 1:3 work: rest ratio is sufficient for isometric strength testing and this was applied for all procedures (Blazquez et al., 2013). Failure of a testing position was defined as (1) demonstration of compensatory strategies and (2) the inability to complete a repetition (Clarsen et al., 2014). The test positions are illustrated in Figure 3.6 The scaption position is a position in standing where contraction happens in the scapular plane. The movement in the scaption position refers to lifting the arms up from the side (abduction of the GHJ) in a 45 degree forward alignment (Figure 3.6: A). The prone-Y position is a position whereby the participant lies on the stomach with the arms up in forward elevation in a “Y” position (Figure 3.6: B).

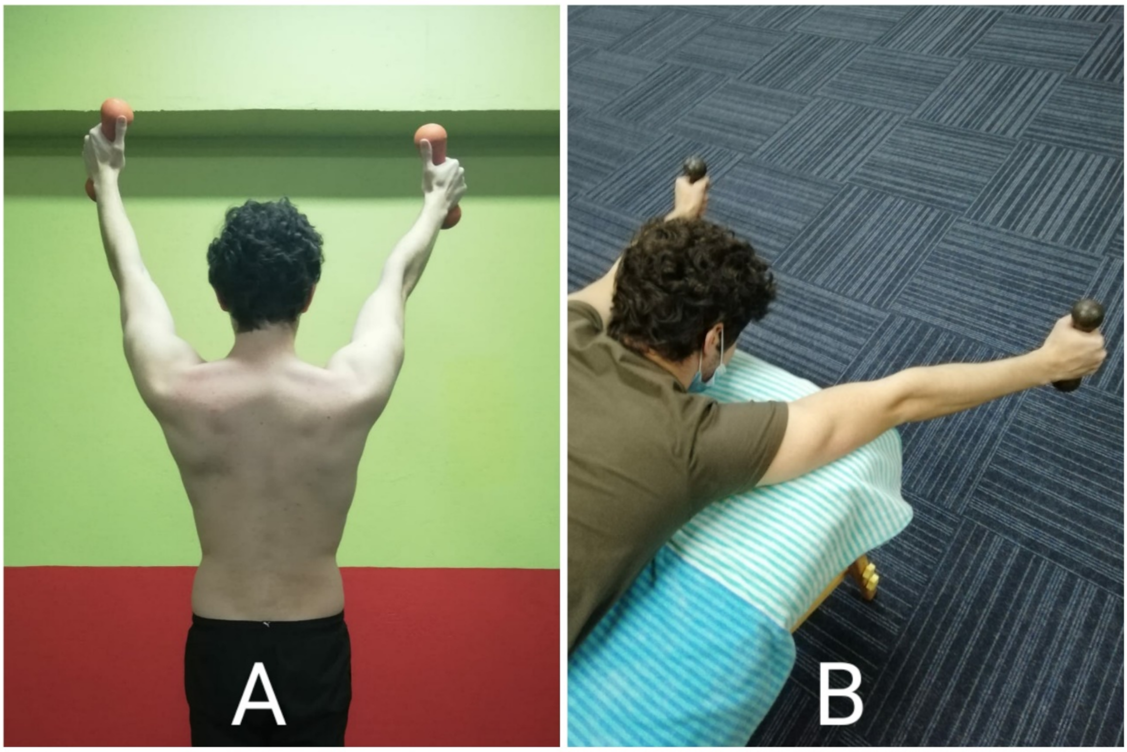


Figure 3.6: Fatigue testing

A: Scaption position, B: Prone- Y position

<u>Closed kinetic chain upper extremity stability test (CKUEST)</u>

Participants performed the CKUEST by assuming a push-up position with their backs' parallel to the floor, as flat as possible, and their hands 36-inches apart (Figure 3.7: A). The upper extremities were positioned perpendicular to the floor and over the hands. Two lines were measured to be parallel and marked on the floor to determine the beginning placement of the hands.

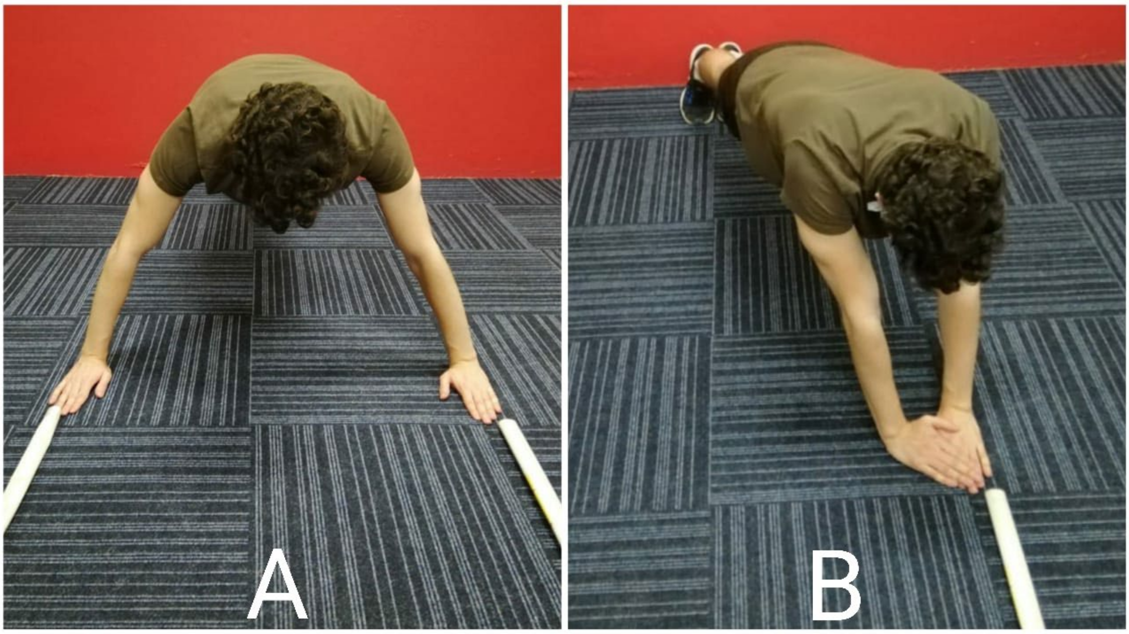


Figure 3.7: Closed kinetic upper extremity test procedure

Participants had 15 seconds to lean over one hand, pick up the opposite hand, reach over to touch hands and return to the starting position. The goal was to achieve the highest number of touches in 15 seconds, by repeating the aforementioned procedure (Tucci et al., 2014).

During the conduction of the CKCUES procedure, the physiotherapist was responsible for: counting the number of touches the participant made in 15 seconds; normalisation of the score (i.e. dividing the number of touches by the participant's height); and calculation of the power score (i.e. multiplying the average number of touches with 68% of the participant's body weight in kilograms, divided by 15) (Tucci et al., 2014).

3.6 WEEKLY INJURY MONITORING

Research Electronic Data Capture (REDCap) - a metadata-driven methodology and workflow process for providing translational research informatics support was used to distribute and collect data from the questionnaires. The captured data was then converted to Microsoft Excel format and IBM SPSS Statistics 26 was used to analyse the data (Harris et al., 2009).

The weekly injury monitoring questionnaire combined with the bowling and training workload questionnaire was sent out using REDCap. This questionnaire was sent out after the first match of the 2018/19 season using the REDCap online platform (Harris et al., 2009). This questionnaire has been adapted from a previous study (Olivier et.al, 2015). Injury data, such as the mechanism of injury and all factors related to the injury event, were assessed by the questionnaire (Appendix: B).

Each Northern Cricket Union Premier Cricket League fast bowler was automatically assigned a study number by REDCap. A unique URL to the questionnaire was then created by REDCap for each participant. The unique URL ensured that the results logged by each questionnaire had corresponded accurately with the relevant Northern Cricket Union Premier Cricket League fast bowlers. The URL list displaying the relevant amateur FB's details was then stored by the researcher in a password protected Excel file. Each amateur FB was emailed their unique URL and which explained that when partaking in any aspect of the study that no names will be used if results are presented in any format so that there is no compromise of anonymity.

They were also informed that they could have asked any questions at any time of the study, participation was completely voluntary and that they would not have suffered any repercussions should they have decided not to partake in or to withdraw from this study at any stage.

The fast bowlers were then followed throughout the season to investigate injury incidence and track their bowling and training workload by means of the weekly questionnaire.
Weekly emails were sent to all participants as a reminder to complete the questionnaire. This weekly questionnaire was the injury surveillance questionnaire (see Appendix: B).

A summary of the results from the baseline tests as well as the weekly questionnaire was transferred to the collective data capturing sheet by the researcher (Appendix F).

3.7 SUMMARY OF THE METHODOLOGICAL PROCEDURE

The 2018/19 cricket season commenced on the 10th of October 2018, the baseline questionnaires were sent out and the baseline testing procedures were executed from the 10th of September 2018 up to the commencement of the season. The weekly questionnaires were sent out weekly from the commencement of the season (10 October 2018) up until the end of the season. Injury incidence was monitored for seven months, over the course of the 2018/2019 cricket season. Only non-contact, shoulder pain was included in the statistical analysis because of the nature of the risk factors investigated. Shoulder injury was defined as: *“any shoulder pain (time-loss and/or non-time-loss) that required medical attention and had the potential to affect cricket training or playing.”* (Orchard, Ranson, et al., 2016). The participants reported injuries (monitored and managed by the primary researcher) through the REDCap questionnaire platform (Harris et al., 2009).

It is important to note that the season commenced later than usual and the teams did not all resume activity at the same point. Some teams were still playing qualifiers to enter the premier league from the promotional league and some teams were playing in club championships. The concurrently running leagues meant that the data collection procedure started even later than expected. The timelines would therefore not be the same between amateur fast bowlers from different teams. This made bowling and training workload difficult to monitor and resulted in this factor being unable to analyse in terms of association. Figure 3.8 below outlines the procedure of the methodology of Study 1.

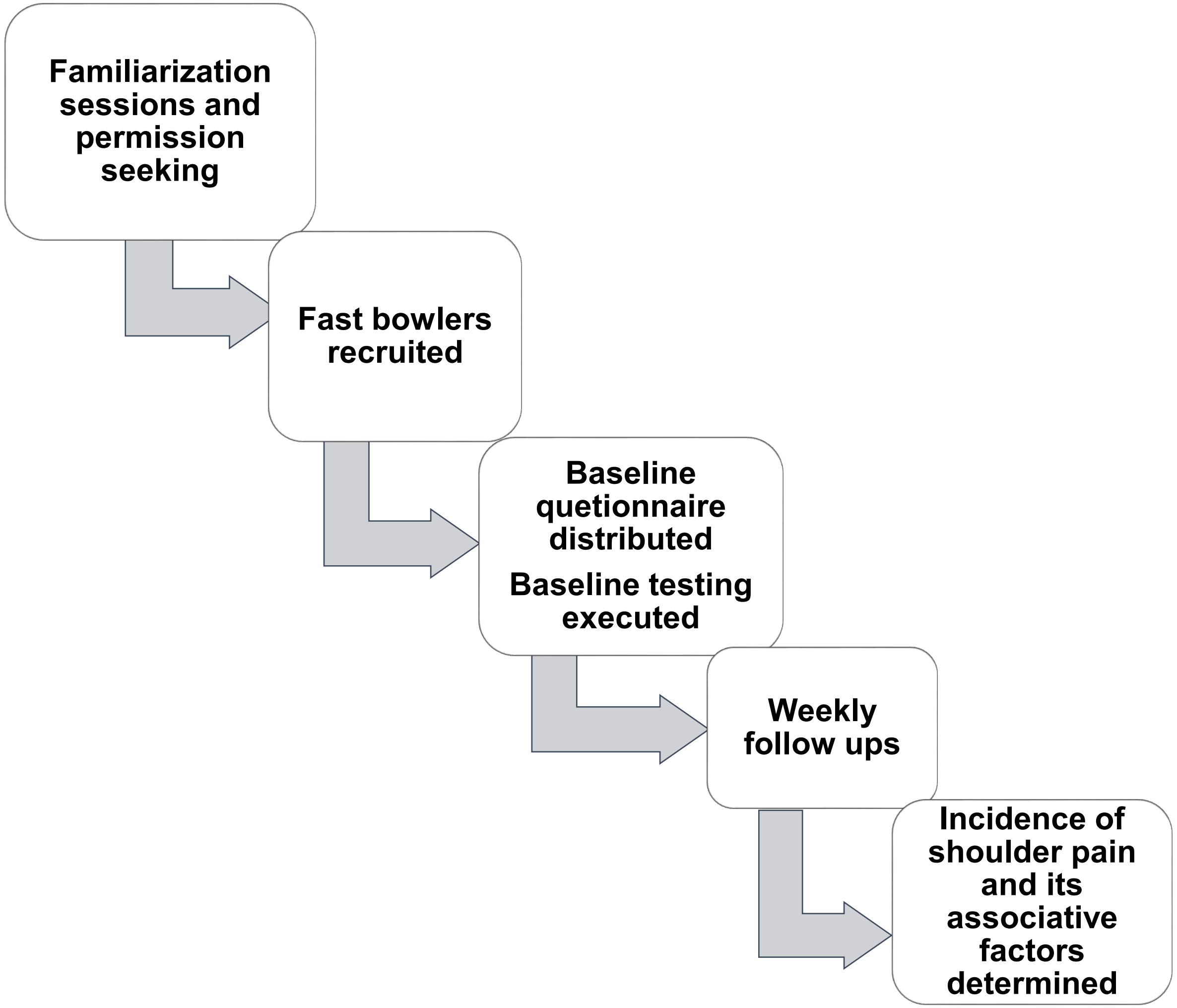


Figure 3.8: Overview of the process of the data collection procedure in study one

3.8 DATA ANALYSIS STUDY ONE

Due to the lower than expected response rate and number of volunteering fast bowlers, independent T-tests were used to analyse the differences between the two groups in the normally distributed continuous variables. The Mann Whitney U tests were used to analyse the continuous variables that were not normally distributed. Categorical variables were analysed for associations by means of either a Chi square test or a Fischer's exact test. Once captured, data were visually inspected for extreme values. No missing data was encountered.

Significance testing (i.e. determining the p-value) means that the probability of the null hypothesis being rejected or not, is determined (Pautz, Olivier, & Steyn, 2018). However, this type of statistical significance does not determine or examine the importance of the relationships between the variables. In order to ascertain the effect of the differences or relationships between these variables one can make use of effect size indices (Pautz et al., 2018).

Effect sizes are important measures to determine the possibility of an effect of a variable on a small population (Pautz et al., 2018). An effect size of 0.1 may be judged to have a small effect, 0.3 a medium effect and 0.5 a large effect on outcomes. It has been defined that an effect size of 0.3 and higher can be said to be having a 'greater than average influence' on the outcome (or in the case of the current study, shoulder pain) (Cohen, 1988; Hattie, 2009). The following effect size calculations were applied: Hedge's G (for the parametric continuous variables, calculated by dividing the difference between the means by the pooled standard deviation); probability of superiority (for the non-parametric continuous variables calculated by dividing the Mann-Whitney U statistic by the (the number of members in group 1) x (the number of members in group 2); and Phi co-efficient (for the non-parametric categorical variables it is equal to the square root of [the Chi squared statistic divided by the total number of observations]) (Cohen, 1988).

Each of the variables were analysed according to whether they were continuous or categorical and then further analysed according to normality. Table 3.2 below indicated the normality of each variable and the tests then used to calculate the significant testing.

Table 3.2: Normality and significant testing of the continuous variables

Variable	Normality-Distribution	Statistical test	P
Weight	Normal	T-test	0.90
Height	Normal	T-test	0.60
CKUEST NS	Normal	T-test	0.44
S RC R	Normal	T-test	0.58
S SA L	Normal	T-test	0.90
PASS ER	Normal	T-test	0.01
PASS IR	Normal	T-test	0.15
ACT ER	Normal	T-test	<0.001
ACT IR	Normal	T-test	0.23
BS Scaption position	Normal	T-test	0.51
CKUEST NO	Not-normal	MWU-test	0.67
CKUEST PO	Not-normal	MWU-test	0.63
S RC L	Not-normal	MWU-test	0.68
S MR L	Not-normal	MWU-test	0.59
S MR R	Not-normal	MWU-test	0.11

S D L	Not-normal	MWU-test	0.70
S D R	Not-normal	MWU-test	0.68
S SA R	Not-normal	MWU-test	0.75
ARC PASS	Not-normal	MWU-test	0.46
ARC ACT	Not-normal	MWU-test	0.80
BS prone-Y position	Not-normal	MWU-test	0.55

*Abbreviations: CKUEST (closed kinetic upper extremity test), NO (number of touches), PO (power score), S (Isometric strength test), RC (rotator cuff), R (right), L (left), MR (medial rotation), D (deltoid), SA (serratus anterior), PASS (passive ROM), ER (external rotation), IR (internal rotation), ACT (active ROM), BS (Borg scale), MWU (Mann-Whitney U statistic).

In order to calculate risk factors for shoulder pain, a multivariable logistic regression analysis was intended to be employed, which would have enabled the medical team to predict shoulder pain. It was impossible to employ a multivariate logistic regression due to the lower than intended number of volunteering and responding participants (39). Thirty-nine participants was not enough to employ a multi-variate logistic regression.

3.9 RESULTS

3.9.1 Participants

Of the 132 amateur club-level (playing for premier league cricket clubs) cricketers of which around 72 were fast bowlers, 43 male fast bowlers (all-rounders included) completed the pre-season screening battery (60% of the population, Figure 3.9). Four were excluded (left the study (n=3); stopped playing cricket (n=1)). This resulted in a sample of thirty-nine (n total =39) amateur fast bowlers (mean age, 23.9 years; mean body mass index, 25.3kg; fast bowlers, 13; all-rounders, 26; right dominant, 37, left dominant, 2). One participant exited the study due to the fact that the participant discontinued competitive cricket due to work commitments. The other three did not complete the questionnaires and in not doing so they have recused themselves from the study (no consent obtained).

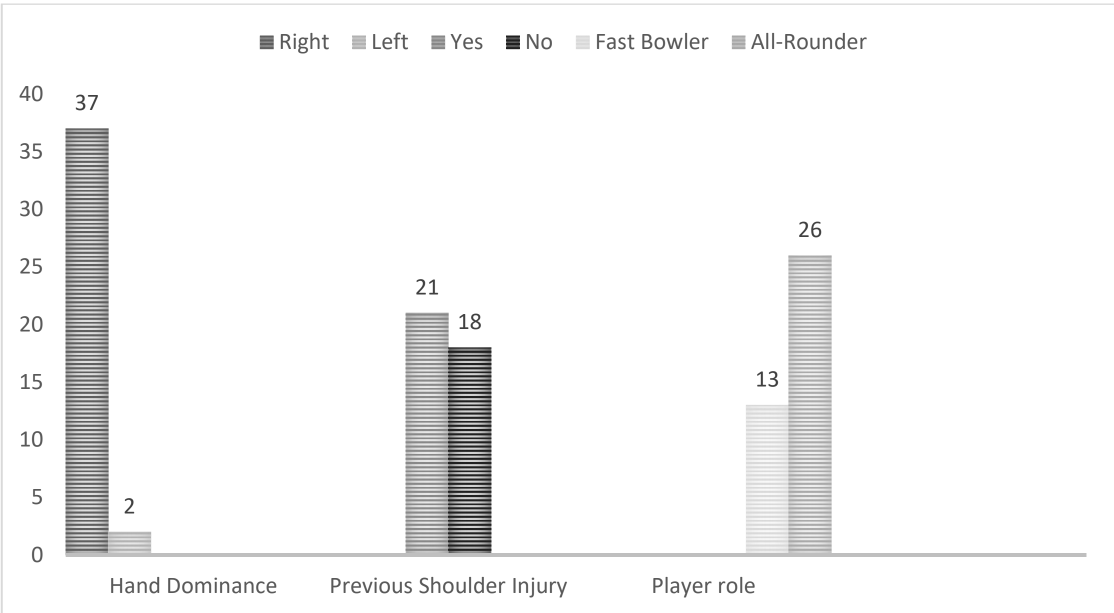


Figure 3.9: Sample demographics

3.9.2 Response Rates

The fast bowlers included in the study had low response rates (average of 10%) to the weekly online questionnaire when the link was only sent via email.

The primary researcher then sent out daily reminders to each cricketer (automatic via REDCap) to complete the questionnaire.

When the amount of responses were deemed less than desired, the researcher then sent out texts and placed phone calls to the partcipants. The participants were all called at the end of the season to verify the data provided and to complete any missing information from the questionnaires.

3.9.3 The Incidence of Injury

Injuries were recorded throughout the season via questionnaires on REDCap, phone calls and text messages. A total number of 9 (23.1%) of the 39 amateur fast bowlers sustained shoulder pain (time-loss and non-time-loss) during the 2018/2019 season (Figure 3.10). One of the nine injuries was an old injury managed by surgery in the year 2014. The injury which resulted in surgery was one of the four injuries/pain which recurred throughout the season and never resolved. This means that the seasonal injury incidence was also 9/39 for the sample population. Seven of the nine injuries were new injuries and two of them were recurring injuries. Of the seven new injuries five had not resolved and continued to produce pain since the onset of injury. Three of the nine injuries (33%) (including the participant who had an operation in the year 2014) was time-loss injuries while six were non-time-loss injuries (67%). Other injuries included (both time-loss and non-time-loss injuries): two finger injuries including one finger fracture; one side strain; three hamstring strains; six cases of lower back pain of which one was diagnosed as a facet joint sprain; one case of iliotibial band syndrome; one case of neck pain; two cases of patella tendinopathy; four elbow injuries including an elbow neuritis, a golfers elbow and two cases of tennis elbow; one anterior talo-fibular ligament sprain of the ankle; one hip flexor strain and one injury which was a scaphoid fracture of the hand which occurred during a fall unrelated to cricket. It is worthwhile to note that the confirmed diagnoses regarding any of the injuries listed above were done by physiotherapists except for the two fractures which was diagnosed via x-ray.

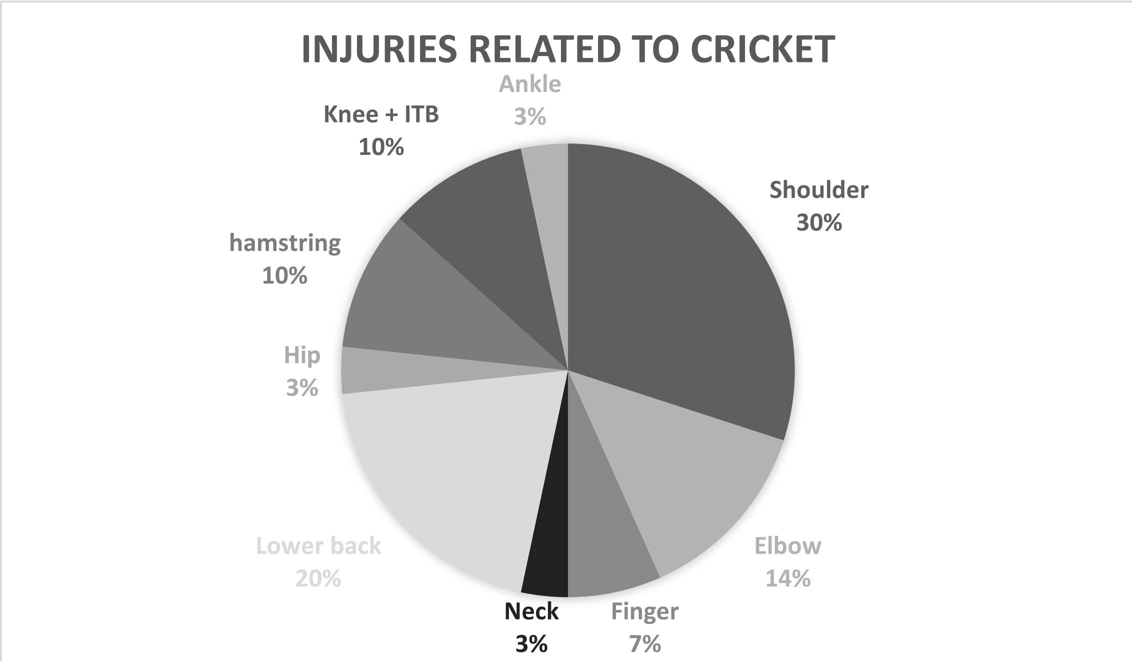


Figure 3.10: Injury percentages in amateur fast bowlers

3.9.4 The Prevalence of Scapula Dyskinesia

Figure: 3.11 below illustrates the prevalence of scapula dyskinesia in premier league fast bowlers. Twenty-six of the 39 fast bowlers in this study presented with scapula dyskinesia. The prevalence of scapula dyskinesia in this population at the beginning of the 2018/19 premier league cricket season was 67%. Of the 26 fast bowlers who presented with scapula dyskinesia at the baseline testing session seven (27%) sustained shoulder pain in the 2018/19 Premier League Cricket season. On the other hand, of the 13 who did not present with scapula dyskinesia only 2 (15%) sustained shoulder pain in the 2018/19 Premier League Cricket season. In the flexion position of the SDT the presence of scapula dyskinesia was 33% in the fast bowlers who had sustained pain in the 2018/19 premier league cricket season whilst in the population sample who did not experience shoulder pain in the 2018/19 premier cricket league season the prevalence of scapula dyskinesia in the flexion position alone was only 11%.

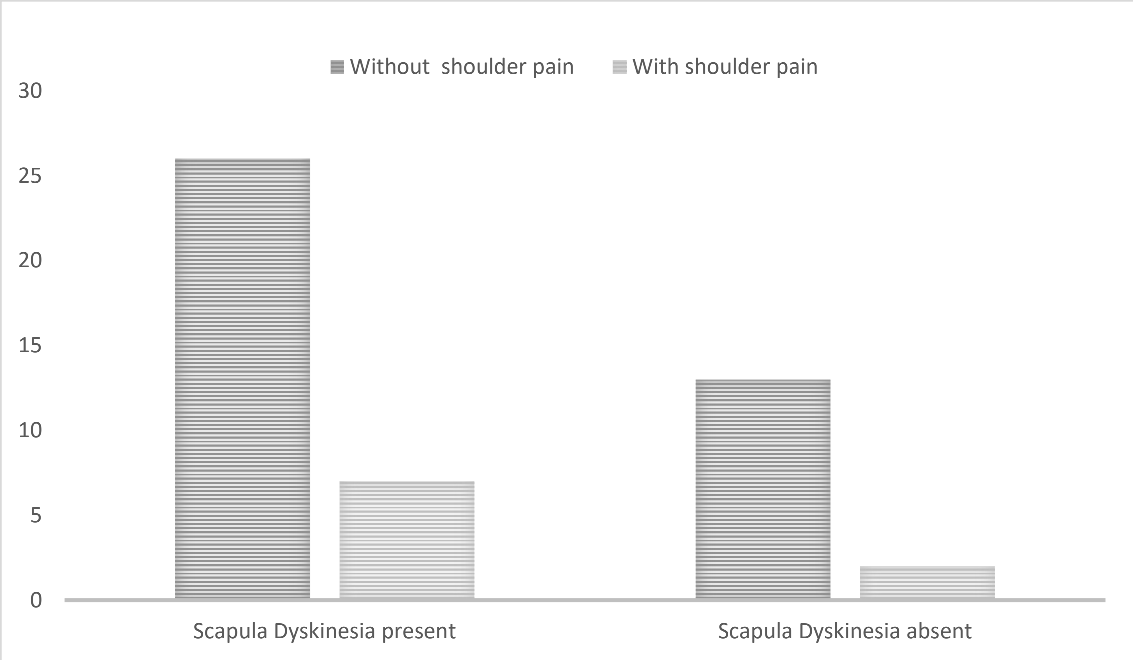


Figure 3.11: Prevalence of scapula dyskinesia

3.10 FACTORS ASSOCIATED WITH THE DEVELOPMENT OF SHOULDER PAIN

The results from the baseline testing sessions were compared with the development of shoulder pain throughout the 2018/19 season by means of the statistical tests described under the Data analysis section (3.10). The results from these tests follow.

Table 3.3: A comparison of the parametric continuous variables between the fast bowlers with shoulder pain and the fast bowlers without (n=39).

Variable	Without shoulder pain n=30 Mean (SD)	With shoulder pain n=9 Mean (SD)	P	Effect size (Hedge's G)
Weight	83.9 (13.6)	83.1 (14.0)	0.90	0.1
Height	1.8 (0.74)	1.8 (0.1)	0.60	0.0
CKUEST NS	10.6 (2.0)	10.0 (1.9)	0.44	0.3
S RC R	15.4 (4.4)	16.3 (3.3)	0.58	0.2
S SA L	24.0 (4.3)	23.8 (4.0)	0.90	0.1
PASS ER	87.6 (13.5)	101.4 (12.5)	0.01	1.0
PASS IR	56.1 (17.2)	46.8 (13.9)	0.15	0.6
ACT ER	78.0 (14.3)	93.7 (14.0)	<0.001	1.08
ACT IR	46.0 (15.3)	39.1 (12.2)	0.23	0.5
BS Scaption position	11.0 (6.2)	12.6 (5.7)	0.51	0.3

*Abbreviations: CKUEST (closed kinetic upper extremity test), NO (number of touches), PO (power score), S (Isometric strength test), RC (rotator cuff), R (right), L (left), MR (medial rotation), D (deltoid), SA (serratus anterior), PASS (passive ROM), ER (external rotation), IR (internal rotation), ACT (active ROM), BS (Borg scale).

Table 3.4: A comparison of the non-parametric continuous variables between the fast bowlers with shoulder pain and the fast bowlers without (n=39).

Variable	Median without shoulder pain n=30 (IQR)	Median with shoulder pain n=9 (IQR)	P	Effect size (Probability of superiority)
CKUEST NO	18.0 (6)	18.0 (3.9)	0.67	0.5
CKUEST PO	69.7 (27)	67.1 (24.6)	0.63	0.5
S RC L	13.25 (5.3)	14.0 (2.5)	0.68	0.5
S MR L	13.0 (3.9)	10.6 (4.8)	0.59	0.5
S MR R	12.6 (6.3)	11.4 (2.4)	0.11	0.3
S D L	19.35 (5.5)	21.7 (6.7)	0.70	0.5
S D R	19.3 (6.0)	20.0 (6.1)	0.68	0.5
S SA R	24.3 (6)	24.1 (4.5)	0.75	0.5
ARC PASS	150.5 (21.0)	143.0 (22.0)	0.46	0.4
ARC ACT	129.5 (27.0)	132.0 (17.0)	0.80	0.5
BS prone-Y position	5.0 (4.0)	6.0 (5.0)	0.55	0.4

*Abbreviations: IQR (interquartile range), CKUEST (closed kinetic upper extremity test), NO (number of touches), PO (power score), S (Isometric strength test), RC (rotator cuff), R (right), L (left), MR (medial rotation), D (deltoid), SA (serratus anterior), PASS (passive ROM), ER (external rotation), IR (internal rotation), ACT (active ROM), BS (Borg scale).

Table 3.5: A comparison of the categorical variables between the fast bowlers with shoulder pain and those without (n=39).

*Abbreviations: SDT (scapula dyskinesia test), W (weighted), SH (shoulder).

Variable	Outcome	Without shoulder pain (n=30)	With shoulder pain (n=9)	P	Effect size (Phi-coefficient)
SH injury history	No	13 (43%)	4 (44%)	1.00	0.2
	Yes	17 (57%)	5 (56%)	1.00	
SDT W	Abnormal	22 (73%)	7 (78%)	1.00	0.2
Flexion	Normal	8 (27%)	2 (22%)	1.00	
SDT W Abduction	Abnormal	12 (40%):	4 (44%)	0.59	0.04
	Normal	18 (60%)	5 (56%)	0.59	
SDT Flexion	Abnormal	14 (47%)	7 (78%)	0.01	0.3
	Normal	16 (63%)	2 (22%)	0.01	
SDT Abduction	Abnormal	12 (40%)	5 (56%)	0.47	0.1
	Normal	18 (60%)	4 (44%)	0.47	
SDT Total	Abnormal	19 (63%)	7(78%)	0.69	0.1
	Normal	11 (27%)	2 (22%)	0.69	

According to Table 3.3, Table 3.4 and Table 3.5 above, scapula dyskinesia (tested using the SDT in positions of weighted abduction and flexion), decreased IR ROM, increased GIRD (glenohumeral internal rotation deficit), increased ER, poor endurance (CKUEST and fatigue testing) and isometric muscle strength of selected muscles surrounding the scapula (Deltoid, Serratus Anterior and the Rotator cuff) provided preliminary evidence of an association to the development of shoulder pain throughout the 2018/2019 season (moderate to large effect sizes of 0.3 and higher). Weight and height showed no difference in the development of shoulder pain in the 2018/19 premier league season.

3.11 DISCUSSION

In this section, the results that were obtained in Study 1 will be discussed.

3.11.1 Injury Definition and Seasonal Incidence of Shoulder Pain in Amateur Fast Bowlers

Bowlers are frequently affected with shoulder pain and injury when compared to the other player roles in cricket (Kumar et al., 2015). From the thirty-nine injury free fast bowlers, nine (23.1%) in this study presented with shoulder pain over the course of the 2018/19 Premier League Cricket season. This is similar to what was found in studies where both time-loss and non-time-loss injuries were included (Dutton, Tam, & Gray, 2019; Ranson & Gregory, 2008). In this study both time-loss and non-time-loss injuries were included and a clear set definition of injury was used (Orchard, Ranson, et al., 2016). In amateur cricketers it would necessary to include player reported injuries based on physical symptoms due to the fact that it is uncommon for an amateur cricket team to have a medical team on staff (Orchard, Ranson, et al., 2016). It is because of this fact that all player reported shoulder injuries and pain was included in this study. Due to the fact that most of the available information regarding shoulder pain in cricketers focussed on elite fast bowlers who commonly have online injury monitoring tools and databases the injury incidence numbers regarding amateur fast bowlers is limited and underestimated. The underestimation could be due to the fact that when cricketers play-through the pain inflicted by injury it would be common practice not to report this in amateur settings where no medical staff is available (Orchard, Ranson, et al., 2016).

Fast bowlers frequently continue to bowl even when they are inflicted with pain (Ranson & Gregory, 2008). This statement holds true when looking at the information derived from this study. Only three of the 39 fast bowlers who experienced shoulder pain lost playing- and/or training- and/or bowling time (in overs bowled). This would mean that had this study only included time-loss injuries, like the majority of the studies available, the incidence would be reflected at only 7.7% which is similar to the information available regarding the incidence of shoulder pain. The underestimation caused by only including time-loss injuries is highlighted by the studies investigating the incidence of injury over a period of 10 years (Orchard et al., 2006).

The incidence of injury described equated to an average of 1% of the injuries noted in the aforementioned study whist another study described shoulder injury incidence at an underestimated 5% (Arora et al., 2015). The inconsistencies noted would justify the need to look into a combination of both time loss and non-time-loss injuries (Ranson & Gregory, 2008).

The incidence of shoulder pain is notably higher in the amateur population (identified in our study as 23.1%) than what has been identified in professional cricketers (18%) and could be attributed to the fact that fast bowlers overhead workload is considerably higher than that of a batter (Dutton, Tam, & Gray, 2019; Ranson & Gregory, 2008). In addition to the reasons mentioned above, one needs to take into account that not only are elite fast bowlers specialised athletes who follow stringent rehabilitation and warm-up and prevention strategies, they also earn a living from playing cricket and have online databases capturing injury data. The current study is set apart as it is the only one of its' kind on amateur fast bowlers and in studying this population and the results obtained from the small sample justifies the initiation of large sample studies on amateur cricketers and fast bowlers alike. The high incidence of shoulder pain displayed in this population also justifies pre-season testing and the increased efforts in identifying amateur fast bowlers at a higher risk for the development of shoulder pain.

3.11.2 Associated Factors to Shoulder Pain

The results from the current study have indicated, through the usage of effect size calculations, that a decrease in IR ROM, an increase in ER ROM, scapula dyskinesia, and muscle strength of selected muscles around the GHJ, endurance and upper extremity stability have moderate effect sizes indicating greater than average influences on the development of shoulder pain. These factors are consistent with the paper by Cools et al. (2015) describing a science based approach to prevent shoulder injuries in overhead athletes, where GIRD, scapula dyskinesia and muscle strength have all been described as possible risk factors (although not scientifically tested) and factors to be addressed to prevent shoulder pain (Cools et al., 2015).

3.11.3 Glenohumeral Internal and External Rotation ROM

Shoulder rotational range of motion was measured using a 10 inch goniometer. Passive and active recordings were taken of glenohumeral (GHJ) IR ROM, glenohumeral ER ROM and then combined to provide the passive and active total arc ROM. Although the total arc ROM, measured both actively and passively, as well as the IR ROM measurements did not indicate statistical significance, the passive and active ER ROM measurements yielded results that indicated differences between the baseline and end of season measurements of the bowlers who developed shoulder pain and the bowlers who did not ($p = 0.01$ and 0.03 respectively) despite the smaller sample size. These results are consistent with previous studies looking into the association between rotational ROM and shoulder pain and injury (Clarsen et al., 2014; Giles & Musa, 2008; Keller et al., 2018; Sundaram, Bhargava, et al., 2012). Passive ER ROM (large effect size: 1.0) in the participants who experienced shoulder pain during the season (all the participants were pain free at the baseline testing session) was notably increased compared to the passive ER ROM in the participants who remained without shoulder pain from the start of the season right through to the end of the season. While the passive internal rotation (large effect size: 0.6) understandably indicated the reverse, that the participants who suffered with shoulder pain (mean: 46.8, SD: 13.9) displayed a notably decreased passive internal rotation ROM when compared to the passive internal rotation ROM in the participants without shoulder pain (mean: 56.1, SD: 17.2). These results indicated that a deficit in glenohumeral internal rotation ROM displayed an association, based on the effect sizes, to the development of shoulder pain throughout the 2018/19 season. Keller et al. (2018) compiled a systematic review investigating GIRD as a risk factor for upper extremity injury in overhead athletes and found that both an increase in external rotation ROM and the decrease in internal rotation ROM favoured the development of injury in overhead athletes. Shoulder rotational dysfunctions, such as an increase in ER ROM and a decrease in IR ROM, have been shown to contribute to chronic shoulder injuries in cricket fast bowlers (Sundaram, Bhargava, et al., 2012). Furthermore, studies have shown that there is a marked increase in ER range of motion, and loss of IR range of motion in cricketers who experienced shoulder pain (Arora et al., 2015; Sundaram, Bhargava, et al., 2012).

The information from these previous studies regarding ROM is consistent with the available literature where glenohumeral internal rotation deficit (GIRD) has been identified in the literature as an associative risk factor for shoulder pain in overhead athletes (Giles & Musa, 2008; McClure et al., 2009; Saccol et al., 2016). This is due to the fact that biomechanically, fast bowling requires the shoulder to initiate the bowling action (wind up and cockup) by externally rotating into the end of ER ROM followed by the maximal contraction of the shoulder internal rotator muscles to continuously contract during the speeding up phase of the delivery. This happens while the external rotators of the shoulder contract to stop the movement once the ball is released (wind up, cockup, acceleration, deceleration and follow through) (Dhakate Darshana, Yeole, Mhatre, & Khatri). The aforementioned movement results in the habitual positioning of the GHJ in excessive ER while not allowing the full range of IR ROM leading to a glenohumeral internal rotation deficit and an increase in ER range of motion, similar to the results of the current study (Comerford & Mottram, 2001).

3.11.4 Scapula Dyskinesia

The positions of the components tested in the SDT (McClure et al., 2009) were flexion and abduction of the GHJ as well as weighted flexion and abduction of the GHJ. Of all the components of the SDT tested none indicated statistical significance and all displayed minimal effect sizes except the non-weighted flexion component of the SDT (p: 0.01) (effect size: 0.3). The moderate effect size displayed could be due to the fact that GHJ flexion is the position that every ball bowled by a fast bowler is in at some point, which lead to visible adaptations and impairment in the scapula humeral rhythm. However, the SDT total ratio between the participants with shoulder pain and those without shoulder pain indicated that scapula dyskinesia was 15% more prevalent in the participants who developed shoulder pain in 2018/19 premier league cricket season.

Struyf et al. (2014) indicated, similar to the results of the current study, that none of the scapular characteristics that were tested significantly predicted the development of shoulder pain. In spite of this the athletes of who developed shoulder pain (similar to the participants in our study) displayed an increased severity and prevalence of scapula dyskinesia (Struyf et al., 2014).

The prevalence of scapula dyskinesia (measured at the baseline, using the SDT) in this population at the beginning of the 2018/19 Premier league cricket season was 67% although only 27% of these fast bowlers sustained shoulder pain. This indicates that there is a high prevalence of scapula dyskinesia in fast bowlers of whom many do not present with or develop shoulder pain in the fast bowlers of the Premier Cricket League. The high presence of scapula dyskinesia in bowlers who have developed shoulder pain is consistent with the findings of a study assessing the incidence of scapula dyskinesia where it was concluded that bowlers can function without any disability of the shoulder joint with the presence of scapula dyskinesia (Tendulkar & Mehta). Although it is worthy to note that in the study at hand, in the flexion position of the SDT the presence of scapula dyskinesia was 33% in the fast bowlers who had sustained pain in the 2018/19 premier league cricket season whilst in the population sample who did not experience shoulder pain in the 2018/19 premier cricket league season the prevalence of scapula dyskinesia in the flexion position alone was only 11%. This is understandable as the bowler would spend a majority of the time, whilst bowling, in the flexion position as compared to the abduction leading to adaptations forming mainly in the flexion position easily identified using the SDT. The SDT would therefore, be useful in pre-season and baseline testing procedures in order to identify fast bowlers at a higher risk for the development of shoulder pain.

3.11.5 Upper Extremity Strength, Stability and Endurance

In the current study assessing amateur fast bowlers, there was indication that there is an association between decreased strength, endurance and proprioception and shoulder pain in these amateur fast bowlers. In 2014 fatigue testing, isometric strength testing and the CKUEST was applied to 26 male collegiate American football players (Pontillo et al., 2014). They were tested for strength, endurance and proprioception using a similar methodology as our study. A logistic regression was used to determine if these factors could in turn predict shoulder pain and injury and the results were in concurrence with our study (Pontillo et al., 2014). Similarly to the results of our study, the study done by Pontillo et al. (2014) did not reach statistical significance thus limited generalizability of their results.

3.11.5.1 Isometric Strength Testing Using a Handheld Dynamometer

The isometric muscle strength of the rotator cuff, the medial rotators, the deltoid and the serratus anterior showed large influences (effect sizes 0.5) on the development of shoulder pain in the 2018/19 season (Table 3.3). In the participants who suffered from shoulder pain, the strength of the medial rotators and the serratus anterior (shoulder protractors) was clinically significantly lower than the isometric strength measurements of the medial rotators and the shoulder protractors in those without shoulder pain. In studies assessing the biomechanics of the shoulder joint, decreased rotational strength has been shown to have been associated to shoulder pain in fast bowlers (Achenbach et al., 2019; Olivier et al., 2015b). In a study where overhead athletes were assessed for isometric muscle strength, overhead athletes without shoulder pathology compared to those with pathological symptoms possessed decreased strength and muscular imbalance of the scapular muscles, specifically the medial rotators and the scapula protractors, not unlike the results from the current study (Cools et al., 2005). Not only is strength, or the lack thereof, shown to be associated with shoulder pain and injury but it has also been linked with bowling speed and performance (Anand et al., 2017). These findings are consistent with the available research that substantiates the facts that imbalances in the glenohumeral and scapulothoracic musculature strength are present in overhead athletes with shoulder pain and pathology and therefore stands to reason that the strength of the cuff and the surrounding scapula muscles should form part of a pre-season battery for amateur fast bowlers (Cools et al., 2005; Page, 2011).

3.11.5.2 Upper Extremity Stability and Endurance

Fatigue, proprioception and endurance of the scapula muscles have been associated with the development of shoulder pain in overhead athletes (Kibler et al., 2013). Functional tests should be included in a cohort of baseline testing procedures in order to provide quantitative data and the CKUEST is a performance test providing functional information regarding the stability and endurance function of the shoulder (Tucci et al., 2014). The current study assessed the upper extremity stability and endurance of fast bowlers playing at an amateur level using the CKUEST and the prone-Y and scaption testing (up to fatigue using the Borg scale) positions.

Due to the decreased availability of participants and resulting small sample size the results regarding the CUKEST and fatigue testing in both the prone-Y and scaption testing positions did not indicate statistical significance, however the CKUEST and the fatigue testing in the prone-Y position displayed significantly greater than average influences (moderate effect sizes 0.5 and 0.4 respectively) on developing shoulder pain in the 2018/19 premier league season. Similar to the results of the current study, excessive downward rotation or decreased upward rotation of the scapula due to poor endurance and activation of the lower fibres of trapezius have been related to shoulder pain in cricketers and overhead athletes alike (Arora et al., 2015; Struyf et al., 2014). The prone-Y position fatigue testing had a greater effect on the development of shoulder pain in the 2018/19 premier league season than the scaption position, which correlates with the literature describing a deficit in the strength of the lower fibres of trapezius and upward rotation as associated factors to the development of shoulder pain and pathology (Camargo & Neumann, 2019; Page, 2011). Like the results of the current study, fatigue has been shown to negatively affect proprioception, which in turn affected bowling accuracy and the positioning of the shoulder, resulting in shoulder pain (Weerakkody & Allen, 2017). Due to the fact that endurance, proprioception and fatigue are shown to have been related to the development of shoulder pain as well as decreased bowling performance in both the available literature and the current study, these associative factors should be addressed in prevention and rehabilitation strategies for shoulder pain in overhead athletes and fast bowlers alike.

3.12 STRENGTHS AND FUTURE RESEARCH CONSIDERATIONS

The longitudinal cohort design of this study is a strength of this study in this population. There is limited information available regarding amateur fast bowlers and the majority of the information regarding fast bowlers of any player level (mostly elite fast bowlers) are either from studies using recall strategies or retrospective data.

This is the only study of its kind in amateur fast bowlers. In addition to the above, the baseline screening procedures all had good reliability and validity values adding quality control and assurance to the values obtained. The testing procedures were also performed by research assistants who were physiotherapists trained in the execution of each baseline test.

Injury reporting was also coordinated by a physiotherapist through weekly reminders and individual check-ins, indicating that the incidence of injury was effectively calculated. The influence of the associated factors on performance-constituents such as bowling speed and accuracy should be investigated and considered in the development of screening protocols and injury prevention programmes. Further studies, exploring the effectiveness of modifying these associated factors, can be used to substantiate or refute the predictability of shoulder pain of these tests. Future studies can also be done to investigate the effect of shoulder pain on the functional performance of fast bowlers. Comparative studies should be initiated in order to determine the influence of the amateur fast bowlers' technique in correlation with the factors determined to contribute to shoulder pain in this population.

3.13 LIMITATIONS

The responses to the online weekly questionnaires were limited due to poor dedication to the study requirements, level of play and availability of mobile data or internet of the fast bowlers. Due to the amateur nature of the league, many of the teams had low turnouts to practice sessions. At the lower ranked premier cricket league clubs there were no available practice sessions to attend. Due to the fact that many of the lower ranked teams have no history of dealing with medical staff and physiotherapists, the management staff did not encourage participation in the manner that the higher ranked teams in the league did. This led to a less than desired amount of participation from the lower ranked teams and hindered the population size which possibly contributed to the results not reaching statistical significance. Also, a larger sample size will allow for predictive models and multi-variate regression analysis which will allow for predictive models to be developed and assessed.

One solution to overcome the general problem of low sample sizes in studies assessing amateur sportsmen and athletes alike is to put data sharing agreements between different countries in place. The current study sample comprised of only fast paced bowlers and future studies should look into all the bowlers and cricketers in the amateur (premier league) teams as they all perform overhead activities. By including all amateur cricket players, it allows for predictive modelling as well. Cricket is an ever-growing, popular, global sport.

At the level at which this studies' population competes (amateur cricket) the amateur fast bowlers are willing to increase training and practice sessions and this in turn increases bowling and training workload in order to evolve into elite/professional statuses. It is, however, very difficult to monitor workload in the amateur fast bowler population as they do not always have physiotherapists and coaches full time on staff. This limited the ability of the researchers to collect accurate data on the influence of the amateur fast bowlers' bowling and training workload on the development of shoulder pain. Future, larger scaled studies, can employ physiotherapists to assess any shoulder pain at the onset of the injury in order to accurately diagnose the cause of the pain. This would lead to differentiation between the types of injury and lead to better development of prevention and rehabilitation strategies.

3.14 CONCLUSION

The incidence of shoulder pain in male amateur fast bowlers from the Northern Cricket union premier cricket league is 23% which is elevated when compared to studies assessing the incidence of shoulder pain in elite fast bowlers.

The prevalence of scapula dyskinesia in male amateur fast bowlers from the Northern Cricket Union Premier Cricket League is 67%. There are many fast bowlers who present with scapula dyskinesia and no shoulder pain. The fact that scapula dyskinesia is highly prevalent (67%) in the current population with no relationship to pain and pathology is consistent with the findings from previous studies and could be due to the biomechanical adaptations resulting from the overhead activity of bowling.

Decreased IR ROM, GIRD, increased ER of the dominant arm, poor endurance and isometric muscle strength of selected muscles surrounding the scapula (Deltoid, Serratus Anterior and the rotator cuff) as well as endurance of the dynamic stabilisers did not reach statistical significance regarding its association to shoulder pain. However, these variables were all indicative of greater than average influences on the development of shoulder pain throughout the 2019/2020 season as they all displayed moderate to large effect sizes and (0.3 and higher). During pre-season testing, it would be beneficial to include the cohort of baseline tests used in this study in order to identify fast bowlers at a higher risk for the development of shoulder pain.

The biomechanical factors shown to have a moderate effect on the development of shoulder pain in amateur fast bowlers should be addressed in order to develop rehabilitation and treatments strategies in these amateur fast bowlers. Due to the fact that many of these fast bowlers have no access to a medical team on staff it would be highly feasible to attempt to decrease the burden of shoulder pain in these amateur fast bowlers by developing self-managed shoulder pain rehabilitation and prevention strategies such as exercise programmes addressing these biomechanical factors associated to shoulder pain in amateur fast bowlers.

It stands to reason that (if proven effective) an exercise programme addressing the biomechanical factors associated to shoulder pain in amateur fast bowlers could prevent shoulder pain by executing the exercise programme pre-season and during the amateur cricket season. In Chapter 2 evidence based exercises were suggested to address the most commonly associated factors to shoulder pain in overhead athletes. In Study 1 the incidence of and the associated factors to shoulder pain in amateur fast bowlers were determined. In Study 2, Chapter 4, that follows, an evidence based exercise programme developed to address these associated factors is refined and validated by means of a modified e-Delphi. A summary of the entirety of the study and the effect of each study on the combined project can be seen in Chapter 6 (Figure 6.1).

CHAPTER 4: STUDY 2, AN EXERCISE PROGRAMME TO ADDRESS THE BIOMECHANICAL FACTORS ASSOCIATED TO SHOULDER PAIN IN AMATEUR FAST BOWLERS – A MODIFIED E-DELPHI STUDY.

4.1 INTRODUCTION

The knowledge regarding the true incidence of pathology such as shoulder pain will create awareness towards such injuries, leading to focused strategies of treatment and prevention. In order to address the treatment and prevention of shoulder pain in this type of sport, associative factors to shoulder pain was investigated. In Chapter 3: Study 1, the incidence of and associated factors to shoulder pain in amateur fast bowlers was described. The incidence was found to be high (23.1%) in the amateur population of fast bowlers. The associative factors to shoulder pain in amateur fast bowlers were described as decreased IR ROM, GIRD, increased ER of the dominant arm, poor endurance and isometric muscle strength of selected muscles surrounding the scapula (Deltoid, Serratus Anterior and the rotator cuff) as well as endurance of the dynamic stabilisers. These variables were all proven indicative of greater than average influences on the development of shoulder pain throughout the 2019/2020 season as they all displayed moderate to large effect sizes and (0.3 and higher) (Cohen, 1988; Hattie, 2009).

Even though the cohort of tests used in the baseline testing procedure explained in Chapter 3: Study 1, would be useful in identifying fast bowlers at a higher risk for the development of shoulder pain they are not necessary to be done prior to the execution of the exercise programme as the intent of the programme ultimately would be to prevent shoulder pain and injury in the future. The biomechanical factors shown to have a moderate effect on the development of shoulder pain in amateur fast bowlers could be addressed in order to develop rehabilitation and prevention strategies in these amateur fast bowlers.

Due to the fact that many of these fast bowlers have no access to a medical team on staff it would be highly feasible to attempt to decrease the burden of shoulder pain in these amateur fast bowlers by developing self-managed shoulder pain prevention strategies. It stands to reason that if these biomechanical factors associated to shoulder pain in fast bowlers were addressed it would decrease the incidence of shoulder pain thereby preventing shoulder pain in amateur fast bowlers. This was the objective of Study 2, to develop an evidence based biomechanical shoulder impairment exercise programme (using a modified Delphi technique) to prevent shoulder pain in fast bowlers.

4.2 METHODS

4.2.1 Study Design and Setting

A qualitative explorative study was employed (The modified e-Delphi process was conducted through an online testing questionnaire). The Delphi technique is a commonly used as well as an accepted methodology for gathering data from experts in a specific field. The Delphi was designed as a group communication process which aimed at achieving a consensus of opinion on a specific subject (Hsu & Sandford, 2007). The Delphi process has been used in various fields of study such as health and medicine. The Delphi technique is well suited as a method for consensus-building, and in this case by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects (Hsu & Sandford, 2007). The following should be taken into consideration when selecting a Delphi method: subject selection; time frames for conducting and completing a study; as well as the possibility of low response rates (Hsu & Sandford, 2007). A classical Delphi study design involves open-ended questions generating qualitative data, alternatively a modified approach involves the primary researcher identifying issues or in this case associated factors to shoulder pain, through a review of the literature or a baseline study (Trevelyan & Robinson, 2015).

4.2.2 Source of Subjects

Locally qualified physiotherapists working for a minimum of three years in the field of sport physiotherapy were the subjects of the current study. The experts included academics and clinicians with specialities in sport physiotherapy.

4.2.3 Inclusion Criteria

Twelve physiotherapists who have worked with athletes directly as clinicians or indirectly by means of clinical supervision of students and research projects as academics were invited to participate in the study. Researchers who had a minimum of three years working experience whilst registered with the Health Professions Council of South Africa were also invited to participate in the study. No exclusion criteria were applied.

4.2.4 Exercise Programme Development

In Chapter 3, the associated factors to shoulder pain in amateur fast bowlers were determined. These factors included; decreased IR ROM, GIRD, increased ER of the dominant arm, poor endurance and decreased isometric muscle strength of selected muscles surrounding the scapula (Deltoid, Serratus Anterior and the rotator cuff) as well as endurance of the dynamic stabilisers. In Chapter 2, Subsection 2.12, Figure 2.8 exercises to address the commonly associated factors to shoulder pain were presented and summarised. For each of the biomechanical factors suitable exercises were selected and proposed. The proposed exercises in Section 2.3 had to meet the following three pre-requisite criteria:

1. The exercise and its intended purpose had to be substantiated and justified by literature.
2. The exercise addressing the biomechanical factor proven to have been associated to shoulder pain needed to be easily performed at the field-side.
3. The exercise addressing the biomechanical factor associated to shoulder pain was required to have the ability to have been performed without the use of specialised exercise equipment.

This was due to the fact that the fast bowler was intended to perform the exercise at the field-side directly after the warm-up session at each training session or at the convenience of the fast bowler. This exercise programme is intended to, in the long run, prevent shoulder pain and injury without being assessed for a predisposition to injury. The researcher also did not want to limit fast bowlers according to the availability of equipment across the platform of amateur cricket.

These exercises were the scapula wall slide, the prone-Y, the superman-T, eccentric loading of the rotator cuff, the corner stretch and the sleeper stretch. In Subsection 2.12, the basic principles of an exercise programme were indicated as well. The American College of Sports Medicine (2017) described the principles of exercise prescription and an exercise session as: Warm-up, conditioning, cool-down and stretching. The exercise programme adhered to these principles.

Cricketers would have to perform the shoulder pain prevention exercise programme after the warm-up that took place field-side. After the training session and the shoulder pain prevention exercise programme the cricketers would perform a light cool-down session as explained in Chapter 2, Subsection 2.12. The stretching exercises included in the developed programme would be done after the warm-up. The rest of the stretches usually performed by the cricketers would be performed at the end of the session as to adhere to the aforementioned principles of exercise prescription (The American College of Sports Medicine, 2017).

4.3 ETHICAL AND LEGAL CONSIDERATIONS

Ethical and legal considerations were accounted for as approval from the University of the Witwatersrand's Faculty of Health Sciences and Human Research Ethics Committee (Medical) (Appendix; C) was obtained (number: M180410).

Prior to participating each expert signed an informed consent form (Appendix: E). The exercise programme and important facts regarding the procedure as well as expectation regarding the evaluation and rehabilitation programme was emailed to all the experts. A patient information sheet was also given to each expert (Appendix: D). In Appendix E, the written informed consent is attached. The expectations of the expert and the process of the study was explained in layman's terms.

The confidentiality of each expert was protected throughout the study. The experts identified themselves on the questionnaire after which a corresponding number was allocated to each expert. Identities were protected by personal information not being displayed in the data; this data will be stored for a period of no less than ten years. The experts invited to assess the exercise programme bear no costs in the participation of this study. Quality control has been ensured throughout the study. All members of the population were given the opportunity to not participate or leave the study at any point. The primary researchers contact details were included on the participant information sheet.

4.4 THE DELPHI STUDY PROCEDURE

4.4.1 Participant Recruitment

A panel of 12 South African experts in the field of sports physiotherapy were identified. The identified experts in the field of sports physiotherapy were contacted via email and phone call. The participants were emailed participant information sheets and informed consent forms via email.

4.4.2 Delphi Procedure

Two sequential rounds of online questionnaires were sent via email to 10 experts in the field of sports physiotherapy (in cricket) with the aim of refining an evidence based exercise programme to address the identified biomechanical risk factors. A draft list of potentially relevant exercises was developed based on literature (Chapter 2). Attached to the exercise programme was information regarding the aims of the current study with reference to the results from Study 1. Experts were instructed to comment on the exercises in the attached table with regards to: the prescribed dosage; the provided illustration; the importance rating of each exercise; and whether to include/exclude the exercise into the programme. There was also an opportunity to make suggestions and comments.

In Round 1, the panel of experts were asked to rate the importance of each exercise and provide additional suggestions for revisions or new items. The experts were asked to respond within a week of receiving the document and reminders were sent out via email. Consensus was considered/reached if at least 80% of the panel strongly agreed/disagreed that an exercise should be included or excluded. Where agreement was not reached or there are suggestions for altered or new items, these were taken to Round 2 together with an aggregated summary of round 1 responses. The final template was distributed to panel members for approval. Figure 4.1 below outlines the procedure of the methodology of Study 3.

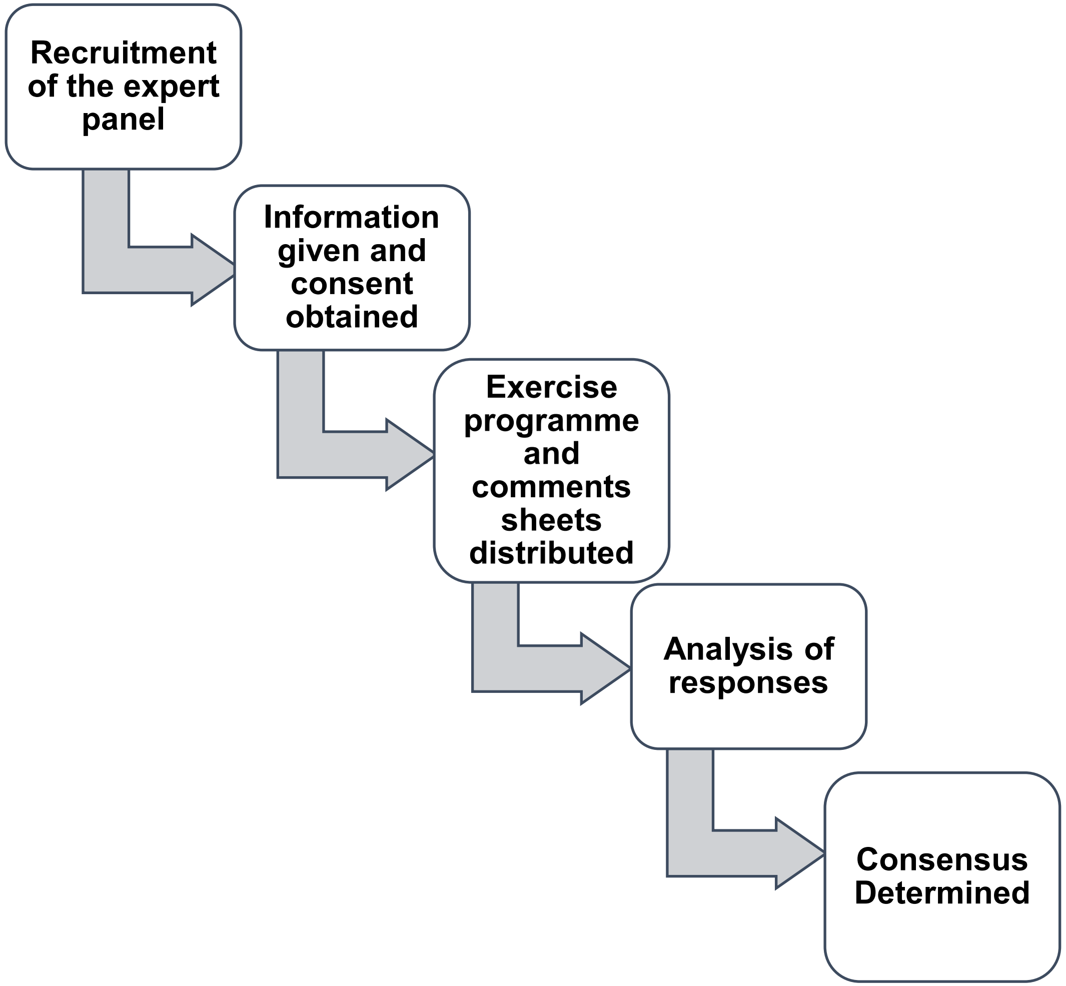


Figure 4.1: Overview of the process of the current Modified e-Delphi

4.5 DATA ANALYSIS

A Delphi process may involve both qualitative and quantitative data (Hsu & Sandford, 2007). The major statistical analysis used in Delphi studies are measures of central tendency (Hsu & Sandford, 2007). Consensus on a topic can be achieved when`70 to 80% of the subjects' votes fall within the same category on a scale (Hsu & Sandford, 2007). In the current study's methodology an exercise was included when 80% of the subjects indicated that the exercise shoulder be included to maximise the validity of the exercise programme.

4.6 RESULTS

The results of the Delphi is divided into two parts, i.e. Round 1 and Round 2. During round one it was evident that many of the experts did not read the participant information sheet attached to the consent form (Appendix: D). It was evident due to the fact that the comments either suggested the usage of equipment or changed the set intention of the exercise. Round two was developed as a reworked Round 1 and is labelled that way.

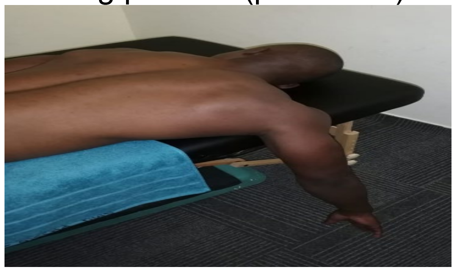
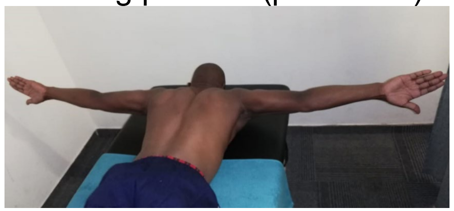
4.6.1 The Expert Panel: Round One

Twelve experts were selected in terms of work experience and qualification. These 12 experts were then contacted. Of the twelve contacted experts, nine responded to round one and were included in the current study. The expert panel consisted of: three academics with PhD qualifications associated with sport or motor control in physiotherapy; one physiotherapist with a Master's degree, associated to sport physiotherapy and biomechanics; and five clinicians who work with, or have worked with, professional cricketers and athletes alike. The experts were allocated numbers at random so that confidentiality was maintained.

4.6.2 The Exercise Programme: Round 1

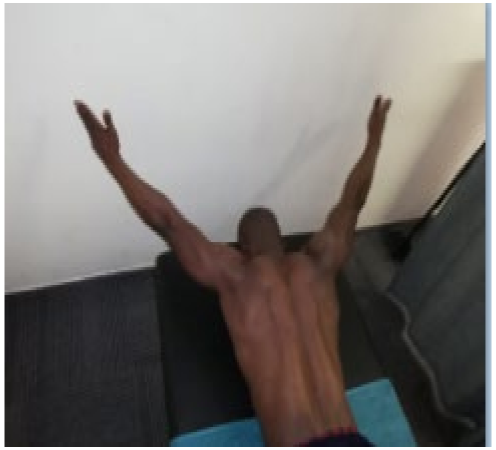
The evidence based biomechanical shoulder impairment exercise programme (referred to as exercise programme in short) and instructions (Participant information sheet) were sent via email to the experts who consented to participate in the Delphi study (Appendix: D). Table 4.1 indicates the exercise programme and data collection sheet. The aim of the Delphi study was described and information regarding the reasons why the exercise programme was developed were also listed. The biomechanical factors found to be associated to shoulder pain related to each exercise were described and justified. The experts were informed that they would have to comment on the exercises included to address the biomechanical impairments associated with shoulder pain. The time limit given for each response was four working days. It was explained that it would take on average fifteen minutes to provide a response. The aforementioned prerequisites were indicated and explained.

Table 4.1 Data Collection Sheet and Exercise Programme Round 1.

Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggestions/Comments
Warm up: 10 Burpees. 10 Push ups. 20 jumping jacks.	N/A	**/10**		
Scapula retraction exercise (superman-T): While lying on a table/bed/bench on your stomach, let the involved arm hang off the side of the table. Turn your hand so your thumb points up. Keeping your elbow straight and your thumb turned up, raise the involved arm up at the side to	2 sets of 15 repetitions once a day. Starting position (position A):  Finishing position (position B): 	**/10**		

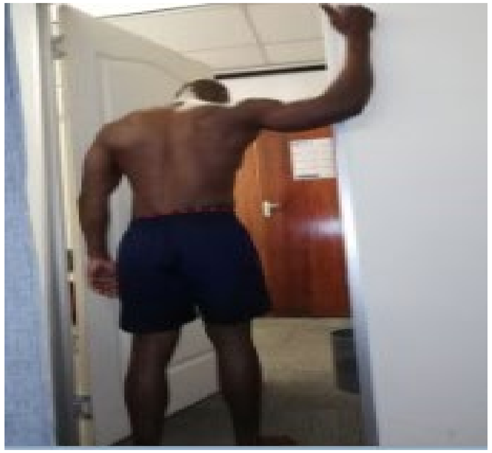
shoulder height. Squeeze or pinch the shoulder blade as you lift the arm.				

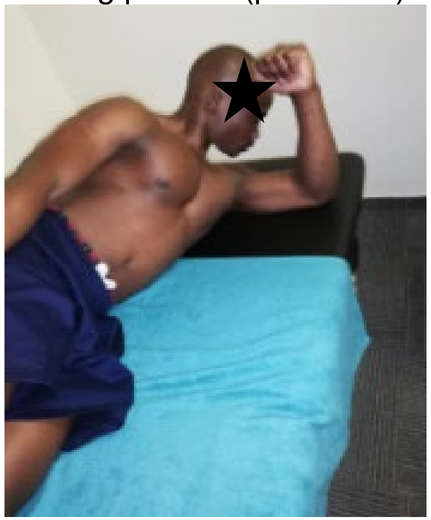
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggestions/Comments**
Scapula wall slide: Stand facing a wall, with your feet 1-2 feet from wall. Bend both elbows 90 degrees and raise arms up to shoulder height. With arms slightly wider apart than shoulder width, slowly lean into wall while sliding forearms up wall. Slowly slide arms down wall and return to starting position.	2 sets of 15 repetitions once a day. Starting position (position A):  Finishing position (position B):	**/10**		

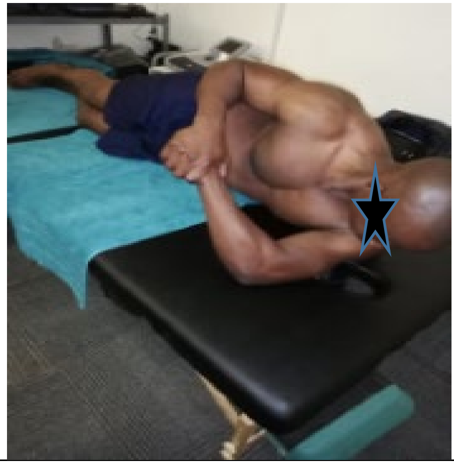
				
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggestions/Comments**
Superman exercise (superman Y): While lying on a table on your stomach, let the involved arm hang off the side of the table/bed/bench. Keeping your elbow straight, raise the involved arm up at a 45° angle (as if you were flying through the air like	2 sets of 15 repetitions once a day. 	**/10**		

Superman). Squeeze or pinch shoulder blade as you lift the arm.				
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggestions/Comments**
Eccentric rotator cuff: Sit with your right arm in position A. Gently pull your right arm from position A to position B (using your left arm) whilst controlling the movement for a count of four seconds.	2 sets of 15 repetitions once a day. Starting position (position A): 	**/10**		

	Finishing position (position B): 			
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggestions/Comments**

Pec Minor Stretch (unilateral corner Stretch): Stand at a doorway and place forearm of involved arm against door frame. Your arm should be out to the side with elbow bent 90 degrees. Keep your back straight and step forward with one leg until a gentle stretch is felt across chest and front of shoulder.	Hold the position for 30 seconds once a day. 	**/10**		

Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggestions/Comments
Sleeper stretch: While lying on involved side on a flat surface, extend involved arm out to the side in front of you. Bend the involved elbow 90 degrees, so that your hand is up in the air. Turn your hand so your forearm is facing down. Using the uninvolved hand, push down on the wrist of the involved arm until a gentle stretch is felt in the shoulder.	Hold the position for 30 seconds once a day. Starting position (position A): 	**/10**		

	Finishing position (position B): 			

4.6.3 Expert Responses Round One

The expert responses are summarised in this sub-section. Each exercises' corresponding responses from each expert is summaried in the tables to follow (Tables 4.2 – 4.7). Of the invited 12 experts, only nine responded and these nine experts' responses were included and summarised.

Table 4.2: Scapula Retraction Exercise (superman-T) Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggestions/Comments
Expert 1	8/10	Include	---
Expert 3	7/10	Include	Instruction to add: Angle the arms closer to the body, not as high into abduction
Expert 4	9/10	Include	The expert suggested that the word squeeze be removed from the instructions. The expert also suggested progression regarding the exercise programme. The therapist also suggested editing the instructions regarding the thumbs facing upward to the thumbs turned downward. The expert also suggested that the amount of sets and repetitions need to be fast bowler specific to each participant.
Expert 5	8/10	Exclude	The expert suggested to add free weights/theraband and a physio ball
Expert 6	7/10	Include	---
Expert 7	8/10	Include	---
Expert 8	8/10	Include	---
Expert 9	8/10	Include	---
Expert 10	8/10	Include	Picture not illustrating instruction, instruction needs to state "thumbs down".
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

Table 4.3: Scapula Wall Slide Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggestions/Comments
Expert 1	9/10	Include	---
Expert 3	9/10	Include	---
Expert 4	7/10	Include	Expert suggested that the aim of each exercise be clarified and instructions be added to activate the correct muscles.
Expert 5	10/10	Include	The expert suggested that a theraband be added around the elbows
Expert 6	8/10	Include	---
Expert 7	9/10	Include	---
Expert 8	9/10	Include	---
Expert 9	9/10	Include	---
Expert 10	9/10	Include	---
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

Table 4.4: Superman Exercise (Superman Y) Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggestions/Comments
Expert 1	6/10	Include	---
Expert 3	5/10	Include	The problem is that this exercise OA UFT, so if the exercise focuses on scapula depression then it is more important. The expert also suggested the usage of theraband.
Expert 4	9/10	Include	The expert suggested that activation instructions be added.
Expert 5	8/10	Include	Add free weights/theraband and a physio ball
Expert 6	8/10	Include	---
Expert 7	10/10	Include	---
Expert 8	8/10	Include	---
Expert 9	6/10	Include	---
Expert 10	8/10	Include	---
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

Table 4.5: Eccentric Rotator Cuff Loading Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggested Exercise/Note
Expert 1	10/10	Include	---
Expert 3	NOT RATED	Exclude	Hand behind back or elastic IR with control
Expert 4	6/10	Include	The expert suggested that dosage should be adjusted to each fast bowler.
Expert 5	2/10	Exclude	An exercise for control of the scapula was suggested.
Expert 6	NOT RATED	Exclude	It was suggested by the expert that the bowler should rather use eccentric rotator cuff in a 90-degree elbow and 90-degree shoulder flexion position. This position is the 'cocking' position which bowlers use during their action.
Expert 7	7/10	Include	---
Expert 8	7/10	Include	---
Expert 9	10/10	Include	---
Expert 10	7/10	Include	---
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

Table 4.6: Pectoralis Minor Stretch (Unilateral Corner Stretch) Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggestions/Comments
Expert 1	4/10	Exclude	---
Expert 3	8/10	Include	---
Expert 4	5/10	Exclude	The expert suggested that the exercise would not be effective in stretching pec minor
Expert 5	10/10	Include	---
Expert 6	8/10	Include	---
Expert 7	8/10	Include	---
Expert 8	7/10	Include	---
Expert 9	3/10	Exclude	The expert suggested that active scapula setting holds will be better suited.
Expert 10	5/10	Exclude	Prone, shoulder 90/135 degrees abduction and using opposite arm rotate over the body keeping the shoulder in the ground to stretch pec major and minor respectively
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

Table 4.7: Sleeper Stretch Expert Responses

Expert Physiotherapist	Importance Rating	Include/Exclude	Suggestions/Comments
Expert 1	7/10	Include	---
Expert 3	9/10	Include	---
Expert 4	8/10	Include	The expert suggested that the stretch be held for two sets of 30 seconds
Expert 5	10/10	Include	---
Expert 6	8/10	Include	---
Expert 7	8/10	Include	---
Expert 8	8/10	Include	---
Expert 9	10/10	Include	---
Expert 10	10/10	Include	---
Expert 2	Expert 2 did not respond to emails and was excluded from round 1		
Expert 11	Expert 11 did not respond to emails and was excluded from round 1		
Expert 12	Expert 11 did not respond to emails and was excluded from round 1		

4.6.4.1 A Reworked Round 1

Two of the nine experts responded within the allocated four working days. Once the allocated time expired, reminders were sent out to experts to complete the Delphi data collection sheet. The total time taken to collect the data from the nine participants for a total of nine responses was two months. This set the timelines back and the researcher had to go to extreme lengths to ensure responses including face-to-face meetings in order to ensure that the participants understood the intent and procedure of the exercises included in the exercise programme. The responses of the participants who replied timeously may have had less input than the experts who had face-to-face contact. Therefore it is plausible to think that the experts who had required less contact were limited in their understanding of the detail expected from their responses.

Five of the nine experts did not make feasible suggestions regarding the proposed exercise programme. Equipment was suggested to be added by three experts. Two experts did not understand the aims of each exercise. One expert did not know the background of each exercise (being substantiated regarding effectiveness with evidence). In addition to the suggestions made related to the exercises it was suggested that the cricketers perform the usual warm up performed at training and or matches. This limited the ability of the researcher to include these suggestions to the final work-up rendering only four responses valid. The researcher subsequently made the decision to rework the information sheet and contact each expert and explain the study in more detail. The need for the exercise programme to be performed field-side without the use of equipment was clarified. It was clearly indicated that the intent of the exercise programme was not to treat shoulder pain. The information regarding the criteria for the exercise individually as well as for the exercise programme in general was included and highlighted in both the email and the actual exercise programme sent out to the experts. The criteria for each exercise were explained and the exercise programme and data collection sheet were adapted by highlighting the impairment each exercise was aimed at addressing. The input regarding the missing information, the clarity of the aims of each exercise and the instruction and positional input was valuable and applied. This constituted the reworked round one of the Delphi study.

4.6.4.2 The Exercise Programme: Round 1 Reworked

One additional expert was added to the panel of experts in order to attain the goal of a 10 person expert panel. This expert was labelled 'expert two'. Each of the experts was called and explained the importance of reading the participant information sheet. The criteria for the inclusion of each exercise were explained as well. The reworked exercise programme and instructions (Participant information sheet) were sent via email to the experts who consented to participate in the Delphi study (Appendix: D). Tables 4.8 – Table 4.13 to follow, indicates the exercise programme and data collection sheet for the reworked version of round one.

The experts were instructed to note the impairment and decide if the exercise is suitable or not. In the event that the expert deemed the exercise not suitable they were requested to replace it with an evidence-based exercise, proven to address the associated impairment.

It was also made clear that the exercise programme would not be treating shoulder pain, it was explained to be meant to decrease the incidence of the biomechanical factors found to correlate with shoulder pain in the first study of the larger study. It was also explained that cricketers would now execute the usual warm-up performed at training sessions and matches.

Each exercise was allocated its own table where the impairment and the aim was clearly described. The comments regarding the instructions were also applied in each of the tables. The last column of the data collection table used in the Delphi study was also adapted to suit the aforementioned instructions distributed to the expert panel. All the aforementioned information is detailed in Tables 4.8 – Table 4.13 below.

Table: 4.8: Scapula Retraction Exercise (Superman-T): Round One Reworked

Impairment this exercise is aimed at addressing: Poor endurance and strength of the shoulder mobilisers and dynamic stabiliser muscles.

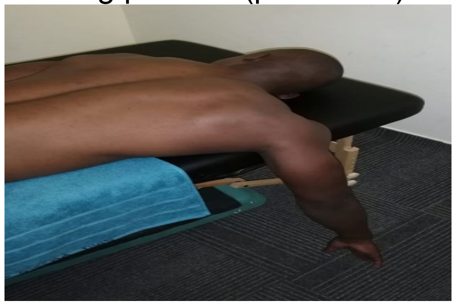
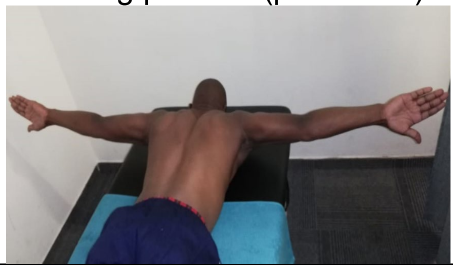
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Scapula retraction exercise (superman-T): While lying on a table/bed/bench on your stomach, let the involved arm hang off the side of the table. Turn your hand so your thumb points down. Keeping your elbow straight and your thumb turned up, raise the involved arm up at the side to shoulder height. Squeeze the shoulder blade as you lift the arm.	2 sets of 15 repetitions once a day. Starting position (position A):  Finishing position (position B): 	**/10**		

Table 4.9: Scapula Wall Slide: Round One Reworked

Impairment this exercise is aimed at addressing: Scapula dyskinesia accompanied by poor dynamic stability of the scapula

Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Scapula wall slide: Stand facing a wall, with your feet 1-2 feet from wall. Bend both elbows 90 degrees and raise arms up to shoulder height. With arms slightly wider apart than shoulder width, slowly lean into wall while sliding forearms up wall. Slowly slide arms down wall and return to starting position.	2 sets of 15 repetitions once a day. Starting position (position A):  Finishing position (position B):	**/10**		

Table 4.10: Superman Exercise (Superman Y): Round One Reworked

Impairment this exercise is aimed at addressing: Poor lower fibres of trapezius activation and endurance of the surrounding shoulder muscles in the prone-Y position.

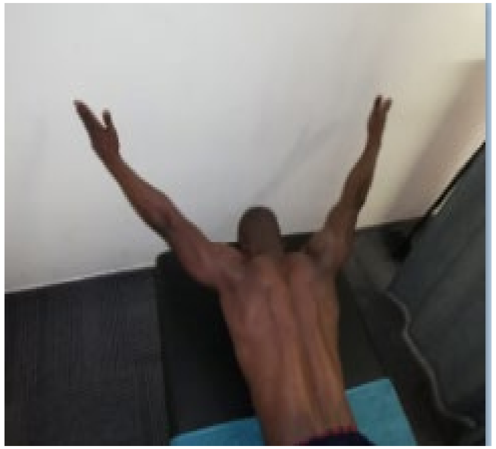
Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Superman exercise (superman Y): While lying on a plinth/bed/table on your stomach, let your arms hang off the plinth/bed/table. Keeping your elbow straight, raise the involved arm up at a 45° angle (as if you were flying through the air like Superman). Pull your shoulder blade downwards as you lift the arm upwards focusing on stabilizing your shoulder blade in order to hold your arms in the position.	2 sets of 15 repetitions once a day. 	**/10**		

Table 4.11: Eccentric Loading of the Rotator Cuff: Round One Reworked

Impairment this exercise is aimed at addressing: Poor eccentric strength of the rotator cuff and scapula dyskinesia

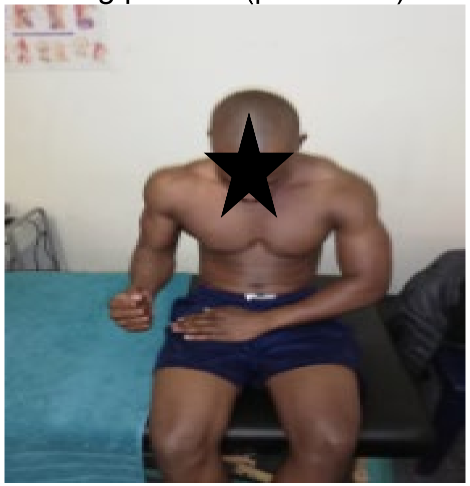
Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Eccentric rotator cuff: Sit with your right arm in position A. Gently pull your right arm from position A to position B (using your left arm) whilst controlling the movement for a count of four seconds.	2 sets of 15 repetitions once a day. Starting position (position A):  Finishing position (position B):	**/10**		

Table 4.12: Pectoralis Minor Stretch (unilateral corner Stretch) Round One Reworked

Impairment this exercise is aimed at addressing: Poor positioning (protraction) of the scapula resulting in scapula dyskinesia.

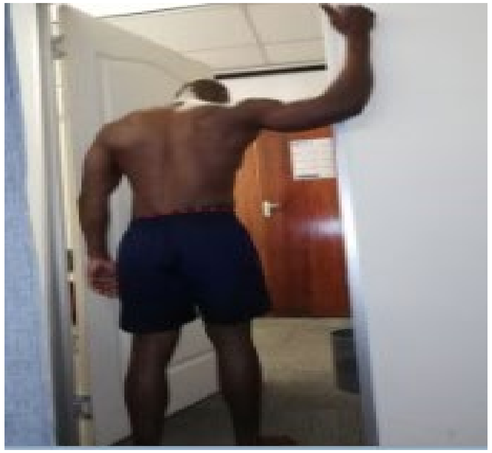
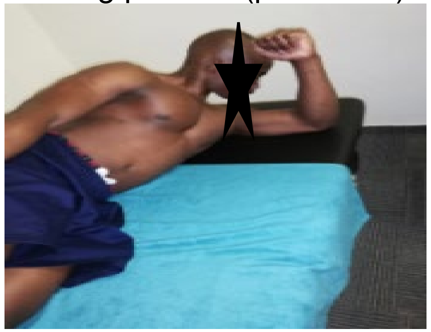
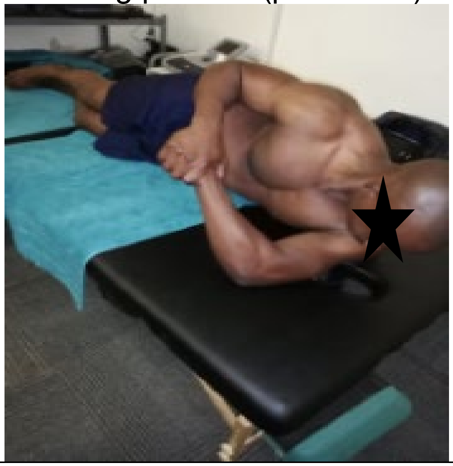
Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Pec Minor Stretch (unilateral corner Stretch): Stand at a doorway and place forearm of involved arm against door frame. Your arm should be out to the side with elbow bent 90 degrees. Keep your back straight and step forward with one leg until a gentle stretch is felt across chest and front of shoulder.	Hold the position for 30 seconds once a day. 	**/10**		

Table: 4.13: The Sleeper stretch Round One Reworked

Impairment this exercise is aimed at addressing: decreased internal rotation and a stiff posterior capsule.

Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Sleeper stretch: While lying on involved side on a flat surface, extend involved arm out to the side in front of you. Bend the involved elbow 90 degrees, so that your hand is up in the air. Turn your hand so your forearm is facing down. Using the uninvolved hand, push down on the wrist of the involved arm until a gentle stretch is felt in the shoulder.	Hold the position for 30 seconds once a day. Starting position (position A):  Finishing position (position B): 	/10		

4.6.6 Expert Responses Round One Reworked

The expert responses are grouped in this sub-section. Each exercises' corresponding responses from each expert is summarised in the tables to follow. Of the invited 10 experts all 10 experts in the panel responded all of which were included below.

Table 4.14: Scapula Retraction Exercise (Superman-T) Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: Poor endurance of the shoulder mobilisers and dynamic stabiliser muscles.

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	8/10	Include	---
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	7/10	Include	---
Expert 4	8/10	Include	The expert suggested that we base the amount of sets and repetitions on each fast bowler individually.
Expert 5	10/10	Include	---
Expert 6	7/10	Include	---
Expert 7	8/10	Include	---
Expert 8	8/10	Include	---
Expert 9	8/10	Include	---
Expert 10	8/10	Include	---

Table 4.15: Scapula wall slide Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: Scapula dyskinesia accompanied by poor dynamic stability of the scapula

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	9/10	Include	---
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	9/10	Include	---
Expert 4	8/10	Include	The expert suggested that we base the amount of sets and repetitions on each fast bowler individually.
Expert 5	10/10	Include	---
Expert 6	8/10	Include	---
Expert 7	9/10	Include	---
Expert 8	9/10	Include	---
Expert 9	9/10	Include	---
Expert 10	9/10	Include	---

Table 4.16: Superman Exercise (Superman Y) Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: Poor lower fibres of trapezius activation and endurance of the surrounding shoulder muscles in the prone-Y position.

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	6/10	Include	----
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	5/10	Include	---
Expert 4	8/10	Include	The expert suggested that we base the amount of sets and repetitions on each fast bowler individually.
Expert 5	8/10	Include	---
Expert 6	8/10	Include	---
Expert 7	10/10	Include	---
Expert 8	8/10	Include	---
Expert 9	6/10	Include	---
Expert 10	8/10	Include	---

Table 4.17: Eccentric Rotator Cuff Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: Poor eccentric strength of the rotator cuff and scapula dyskinesia

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	10/10	Include	----
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	NOT RATED	Exclude	---
Expert 4	5/10	Include	The expert suggested that we base the amount of sets and repetitions on each fast bowler individually. Add the \`sucking in\` of the HOH into the glenoid and perhaps do it in 90 degrees abduction with a small weight that must be controlled against gravity
Expert 5	8/10	Include	---
Expert 6	10/10	Include	Expert noted that it is very important to load the tendon which will help reduce shoulder pain or prevent tendinopathy progression.
Expert 7	7/10	Include	---
Expert 8	7/10	Include	---
Expert 9	10/10	Include	---
Expert 10	7/10	Include	---

Table 4.18: Pectoralis Minor Stretch (Unilateral Corner Stretch) Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: Poor positioning (protraction) of the scapula resulting in scapula dyskinesia.

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	6/10	Include	In the case of using the suggested stretch, patient runs the risk of compensating for pec minor shortening with thoracic or lumbar extension.
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	8/10	Include	---
Expert 4	3/10	Exclude	The expert suggested that this exercise targets the pectoralis major more.
Expert 5	10/10	Include	---
Expert 6	8/10	Include	---
Expert 7	8/10	Include	---
Expert 8	7/10	Include	---
Expert 9	8/10	Include	---
Expert 10	5/10	Exclude	The expert suggested that the exercise be changed to prone, shoulder 90/135 degrees abduction and using opposite arm rotate over the body keeping the shoulder in the ground to stretch pec major and minor respectively.

Table 4.19: Sleeper Stretch Expert Responses (Reworked Round One)

Impairment this exercise is aimed at addressing: decreased internal rotation and a stiff posterior capsule.

EXPERT PHYSIOTHERAPIST	IMPORTANCE RATING	INCLUDE/EXCLUDE	SUGGESTED EXERCISE/NOTE
Expert 1	7/10	Include	---
Expert 2	10/10	Include	Exercise needs to be evidence-based
Expert 3	9/10	Include	---
Expert 4	8/10	Include	---
Expert 5	10/10	Include	---
Expert 6	8/10	Include	---
Expert 7	8/10	Include	---
Expert 8	8/10	Include	---
Expert 9	10/10	Include	---
Expert 10	10/10	Include	---

Table 4.20: Expert Responses Summary (Reworked Round One)

EXERCISE	AVERAGE IMPORTANCE RATING	INCLUDE	EXCLUDE	SUGGESTED EXERCISE/NOTE
Scapula retraction exercise (superman-T)	8.2/10	10	0	1: Exercise needs to be evidence based 2: Angle the arms closer to the body, not as high into abduction 3: Base the amount of sets and repetitions on their individually assessed baseline to ensure principles of overload and specificity 4: Picture not illustrating instruction 5: Usage of a physio ball suggested
Scapula wall slide	9/10	10	0	1: Exercise needs to be evidence based 2: Base the amount of sets and repetitions on their individually assessed baseline to ensure principles of overload and specificity 3: To add theraband
Superman exercise (superman Y)	7.7/10	10	0	1: Exercise needs to be evidence based 2: Base the amount of sets and repetitions on their individually assessed baseline to

				ensure principles of overload and specificity 3: Usage of a physio ball suggested
Eccentric rotator cuff	8/10	8	2	1: Exercise needs to be evidence based 2: Usage of theraband suggested 3: Base the amount of sets and repetitions on individual fast bowlers. 4: Suggested to load the rotator cuff in abduction
Pec Minor Stretch (unilateral corner Stretch)	7.3/10	8	2	1: Exercise needs to be evidence based 2: In the case of using the suggested stretch, patient runs the risk of compensating for pec minor shortening with thoracic or lumbar extension. 3: The expert suggested that the exercise targets pectoralis major.
Sleeper stretch	8.8/10	10	0	1: Exercise needs to be evidence based

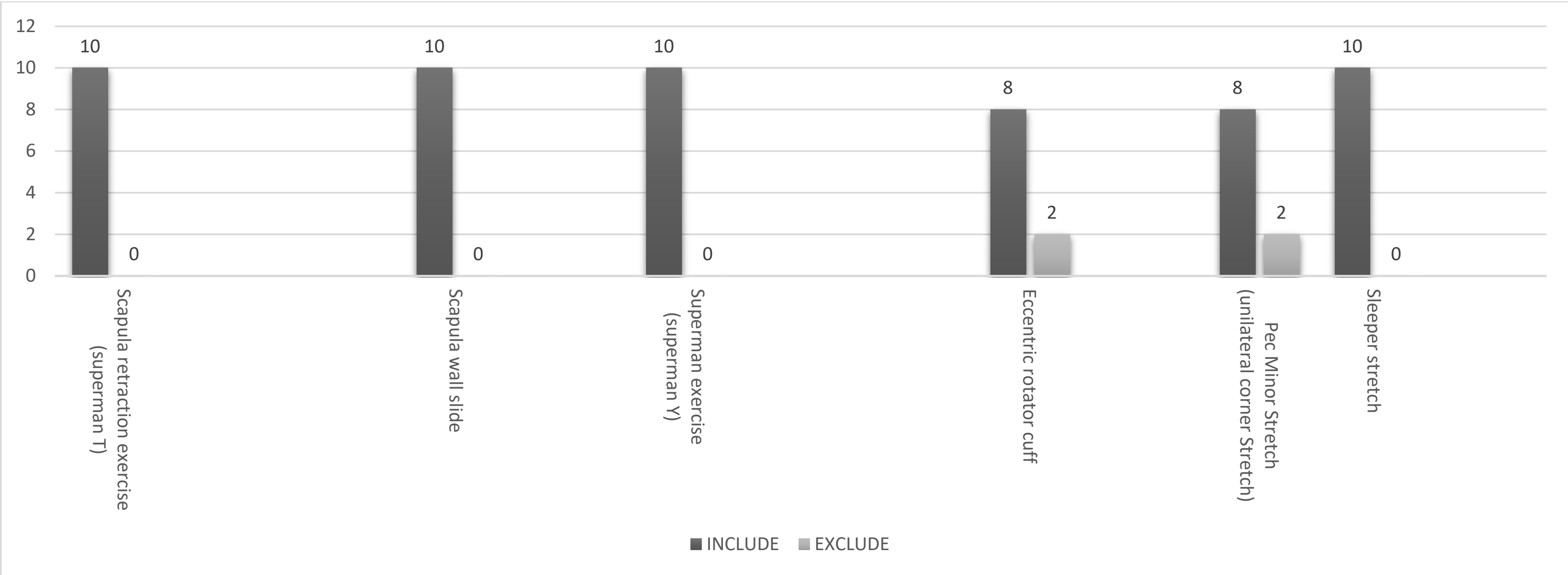
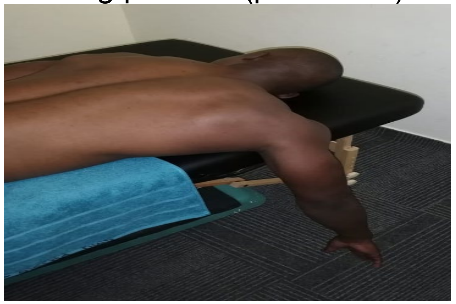
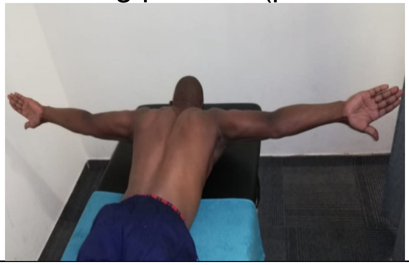


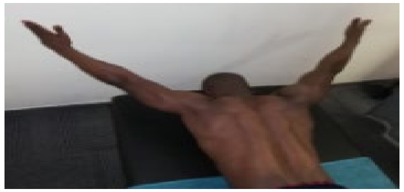
Figure 4.2: Expert report summary

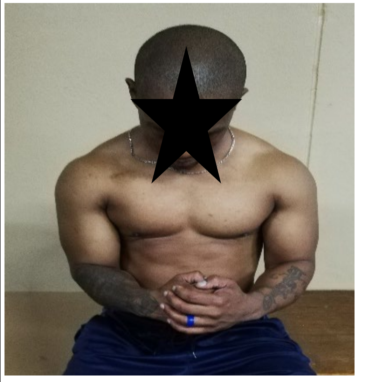
From the responses summarized in Table 4.20 above, it is noted that consensus regarding the exercise programme addressing the biomechanical factors associated to shoulder pain was achieved (80%). Even though consensus was achieved, there was still some valuable information given in the reworked version of round one of the Delphi study by the panel of experts. Fine tuning of the exercise instructions, illustrations and explanations was accomplished and the final exercise programme is displayed below.

Table 4.21: The Final Exercise Programme

Exercise	**Dosage and Illustration**
Exercise 1: Scapula retraction exercise (superman-T): While lying on a table/bed/bench on your stomach, let your arms hang off the side of the table/bed/plinth. Turn your hand so your thumb points down. Keeping your elbow straight and your thumb turned up, raise the involved arm up at the side to shoulder height. Squeeze your shoulder blades as you lift the arm. The squeeze should be felt in your upper back next to your shoulder blades.	**2 sets of 15 repetitions** once a day. If you notice that your form is affected you can pause in between and resume after. Starting position (position A):  Finishing position (position B): 
Exercise 2: Scapula wall slide: Stand facing a wall, with your feet 1-2 feet from wall. Bend both elbows 90 degrees and raise arms up to shoulder height and do not take your arms too far away from the body. **With arms slightly wider apart than** shoulder width, slowly lean into wall while sliding forearms up wall.	**2 sets of 15 repetitions** once a day. If you notice that your form is affected you can pause in between repetitions or sets and resume once the fatigue has subsided.

Slowly slide arms down wall and return to starting position. Tip: make sure the wall surface is smooth and either use a long sleeve top or lubrication on your elbows.	Starting position (position A):  Finishing position (position B): 
Exercise 3: Superman exercise (superman Y): While lying on a table/bed/bench on your stomach, let your arms hang off of the plinth/bed/table. Keeping your elbow straight, raise the involved arm up at a 45° angle (as if you were flying through the air like Superman). Pull your shoulder blade downwards as you lift the arm	**2 sets of 15 repetitions** once a day. If you notice that your form is affected you can pause in between repetitions or sets and resume once the fatigue has subsided.

upwards focusing on stabilizing your shoulder blade in order to hold your arms in the position.	
Exercise 4: Eccentric rotator cuff: Sit with your right arm in position A. Gently pull your right arm from position A to position B (using your left arm) whilst resisting and controlling the movement for a count of **four seconds**.	**2 sets of 15 repetitions** once a day. If you notice that your form is affected or you feel discomfort you can pause in between repetitions or sets and resume once the fatigue has subsided. Starting position (position A): 

	Finishing position (position B): 
Exercise 5: Sleeper stretch: While lying on involved side on a flat surface, extend involved arm out to the side in front of you. Bend the involved elbow 90 degrees, so that your hand is up in the air. Turn your hand so your forearm is facing down. Using the uninvolved hand, push down on the wrist of the involved arm until a gentle stretch is felt in the shoulder.	Hold the position for **30 seconds** once a day. Starting position (position A):  Finishing position (position B):

	
Exercise 6: Pec Minor Stretch (unilateral corner Stretch): Stand at a doorway and place forearm of involved arm against door frame. Your arm should be out to the side with elbow bent 90 degrees. Keep your back straight and step forward with one leg until a gentle stretch is felt across chest and front of shoulder. NB, gently squeeze the bottom of your shoulder blades down and together whilst you are doing the stretch, you should feel this at the base of your shoulder blades. Please take deep breaths as you hold this stretch for 30 seconds.	Hold the position **for 30 seconds** once a day. 

4.7 DISCUSSION

A Delphi technique is recommended as the study design of choice when subjective statements can benefit the addressing of a research matter, when it is easier to have a group survey response then to effectively interact face-to-face, so that a single response or personality of an expert does not influence a group response and so that anonymity can be preserved (Goodman, 1987). The current study's aim fit all of the aforementioned criteria.

In Subsection 4.6 the results of a Delphi study executed to develop a programme addressing the biomechanical factors found to be associated to shoulder pain are displayed (Chapter 3). Round one involved inviting twelve experts to rate the importance and exclude or include exercises forming part of an exercise programme addressing the biomechanical factors associated to shoulder pain (Chapter 3). Of the 12 experts initially invited to execute the methodology of the Delphi study, only nine experts provided responses. Three of the invited experts were excluded due to their lack of responses. These nine experts were included as the expert panel responsible for refining the exercise programme addressing the factors found to be associated to shoulder pain.

4.7.1 Round One

The first round failed due to the experts' misunderstanding of the aim of the exercise programme. The experts in majority either did not read the participant information sheet related to the Delphi study which was attached to the consent form and sent out prior to the email which included the initial Round 1 of the Delphi or the experts failed to remember the instructions by the time Round 1 was received. This lead to the expert panel not understanding that the exercise programme had to be performed field-side and be applied in order to address the factors found to be associated to shoulder pain described in Chapter 3. This was evident through the information derived from the responses in Tables 4.2 to 4.7. The lack of understanding of the exercise programme prerequisites was highlighted by the following comments and suggestions made;

- Suggestions were made to add the use of equipment to the exercise programme.

- The comments made by the experts insinuated that the exercise programme would treat shoulder pain and suggested that certain exercises were not effective in addressing shoulder pain (which was not the aim of the exercise programme).

- Experts suggested that exercises be changed in a way that would then change the aim of the exercise, for example expert nine recommended a scapula setting exercise to replace an exercise intended to increase soft tissue extensibility and ROM (unilateral corner stretch).

- Expert four suggested on several occasions to personalise each exercise to suit each fast bowler.

- Experts suggested that exercises be evidence based even though the exercises were substantiated and based on evidence (this was detailed in the participant information sheet).

If the aforementioned suggestions related to each exercise was applied, the aim of the exercise programme would be altered. In the event that equipment was deemed necessary to affect a change to the impairment found to be associated to shoulder pain the exercise programme would be challenging to be performed field side or at the comfort of an amateur fast bowlers home. If the amateur fast bowler had to purchase equipment it would be difficult to ensure participation and decrease compliance. The aim of the exercise programme was to address the biomechanical factors associated to shoulder pain and not treat shoulder pain. The exercise programme is intended to be generalised to fast bowlers and not specific to any one fast bowlers' pain or pathology or biomechanical impairment, rendering the comments related to this invalid. All of the exercises were evidence-based and this is clearly indicated in the participant information sheet and Chapter 3. Therefore, these exercises have already been substantiated and backed by evidence and the comments regarding the effectiveness of an exercise to accomplish its intended purpose was also rendered invalid.

4.7.2 A reworked round one

The decision to reconstitute or rework the first round of the Delphi study was taken due to the aforementioned limitations in the expert responses. One additional expert was invited to participate and included in the current study, to reach the intended cohort of experts included in the panel. Suggestions made by the experts to the proposed exercise programme were applied when they did not alter the aim of the exercise programme and still met the prerequisites for each exercise included in the exercise programme. The proposed changes included: allowing the warm-up to be fast bowler specific; the warm-up would constitute each fast bowler to perform their usual warm up prior to a bowling session, unclear descriptions of exercise positions were edited and inconsistencies between the instructions of the exercise and the image depicting the exercises were removed. Each exercise was also labelled clearly with reference to the aim of each exercise on the actual data collection sheet. Discrepancies between the instructions and the pictures in the exercise programme were also applied such as the incorrect description of the direction the thumbs should face in the superman-T exercise. The aims and prerequisites of the exercise programme were explained to each expert, as well as the inclusion of each exercise respectively. The suggestions implemented after the failed round one of the Delphi study are displayed in Tables 4.8 to 4.12. All 10 experts provided responses although the timing of the responses proved difficult. Four days were allocated to each expert to provide a response in order to meet the timelines set out by the researcher. The reworked round one of the Delphi study reached consensus as all exercises had an inclusion rate of 80% and above. Table 4.20 summarised the responses of the reworked round one with regards to all of the exercises.

In Subsection 2.12 the literature described has provided substantial evidence that the superman-T and prone-Y exercises are effective in addressing the endurance and dynamic stability around the scapula, the unilateral corner stretch in addressing pectoralis minor length, the sleeper stretch in addressing the length and the tightness of the posterior structures of the shoulder, the scapula wall slide, eccentric loading of the rotator cuff and conscious correction of the scapula positioning effective in addressing the relevant muscle strength, proprioception and endurance of the surrounding scapula muscles. (De Mey et al., 2009; Ronai, 2016).

The scapula retraction exercise known as the superman-T exercise averaged an importance rating of 82% and was included by 100% of the experts and none of the comments or suggestions were applied due to the reasons mentioned above. The prone-Y or the superman-Y exercise yielded an average importance rating of 77% and was included by all the experts as well which was indicative of the fact that the exercise was generally accepted and deemed important. Again, the suggestions by the expert panel regarding these exercises either altered the aim of the exercise and/or did not adhere to the criteria of the programme. The unaccepted suggestions, if applied, would have resulted in the exercise not meeting the perquisite criteria set out by the researcher and described in Chapter 3. The scapula wall slide yielded a 90% importance rating with a 100% average inclusion rate with no responses adequate to be implemented in the final programme indicating that the wall slide was in consensus to be included in the manner that it had been prescribed. The sleeper stretch had a similar response of 88% and was included by all the experts (100%). The eccentric rotator cuff exercise and the unilateral corner stretch, however, had 80% inclusion rates with 80 and 73% average importance ratings respectively, again with no suitable suggestions made by the expert panel. This meant that only one comment regarding the superman-T exercise was usable and implemented (the instruction regarding the thumb pointing downward).

The immediate consensus without much deliberation is one of the limitations regarding a Delphi technique indicative by the information described above. This limitation and the limitations in general and specific to the Delphi process of the current study are discussed in the subsection that follows.

4.7.3 Limitations

Due to the 80 % inclusion rate being met in the reworked Round 1 of the Delphi, consensus was reached. The fact that there were very few implementable suggestions or responses that could have been applied to the final exercise programme the actual adaptation of the programme was limited. Too early and easy consensus is a common limitation with the e-Delphi technique (Donohoe, Stellefson, & Tennant, 2012; MacEachren et al., 2006).

The validation of the exercise programme was determined through one round of the modified e-Delphi study although, in previous studies, on average four sequential rounds of questionnaires are needed before consensus is reached (Donohoe et al., 2012; Hsu & Sandford, 2007). Another issue with the Delphi technique is high attrition rates which fortunately was not the case in the current study, only three experts were excluded from the initial Round 1 and in the reworked Round 1 responses were received from the entire panel of experts. The experts, however, did not stick to the allotted time frame and response times ranged from one day to a month. In combination with the later commencement of the 2018/19 cricket season the delayed responses pushed back the time-line of the entire study and forced adaptations such as the initiation of face-to-face meetings and telephonic reminders. This is a common issue when executing a Delphi study or in this case more accurately an e-Delphi study (Donohoe et al., 2012). An e-Delphi study was originally developed in 2006 in order to computerise the Delphi process and increase efficiency of the technique (MacEachren et al., 2006). The advantages and limitations of the e-Delphi technique was then described and discussed in 2012 (Donohoe et al., 2012). The e- Delphi has many advantages such as convenience, cost effectiveness and easy data management options. Even though internet-based technologies are without a doubt transforming research, the modified e-Delphi has its limitations (Donohoe et al., 2012). The major limitations regarding a modified e-Delphi process were described as; access to the internet, data accuracy, the maintenance of anonymity and the lack of clear instructions (Donohoe et al., 2012). In the current study the experts, in round one, did not read the participant information sheet thoroughly leading indirectly to a lack of clear instructions and a failed round one of the Delphi study. The timing of the Delphi study was not taken into account and it was sent out during a period of heightened sporting- and academic activity leading to distractions and time administration distractions which have also been noted to limit the timeous responses of an e-Delphi (Donohoe et al., 2012). A stringent selection of an expert panel is a prerequisite of a successful Delphi validation process (Eubank et al., 2016). The suggestions and input from the experts in the panel in the current study varied significantly and this could be due to the differences in the experience levels and places of employment of the experts.

Even though a Delphi process such as the one in the current study, may reduce the effects of dominant individuals to coerce fellow panellists, the absence of face-to-face meetings can deprive experts and the primary researcher from exchanging invaluable information regarding the disagreements as well as the clarification of reasons of inclusion and exclusion (Eubank et al., 2016). The limitation regarding the lack of face-to-face meetings hindered the valuable exchange of information and discussion between the primary researcher and the rest of the panel. It was evident that a face-to-face meeting would have assisted the panel in understanding the prerequisites and the aims of the current study. In a paper titled "Delphi methodology in health research: how to do it?", a guideline on how to perform a Delphi technique was discussed due to the lack of the availability of strict guidelines applicable to the usage of a Delphi technique (Trevelyan & Robinson, 2015). The authors highlighted an important point that consensus is not synonymous with the most correct results and the clear description of an expert in the expert panel can mitigate this limitation. The recommendations for future research are based on the limitations discussed in this sub-section and the guideline of how to perform a Delphi technique (Trevelyan & Robinson, 2015).

4.8 FUTURE RESEARCH CONSIDERATIONS

The absence of a face-to face meeting could limit the panels' ability to clarify reasons for disagreement and a final meeting could assist in reaching consensus (Eubank et al., 2016). The recommendation of the current study is that future Delphi studies validating prevention and/or treatment programmes send out the exercise programme using the e-Delphi method described in the study but include a face-to-face meeting to discuss the comments and suggestions at the end of the Delphi process (Eubank et al., 2016). Future Delphi studies of this kind should also include a variety of exercises for each proven or associated factor and/or impairment so that it could increase the validity of the exercise programme. A common question when executing a Delphi study is how many rounds is enough (Trevelyan & Robinson, 2015). In the current study consensus was used as a stopping guideline and consensus was obtained after the reworked round one.

Future studies are recommended to have three rounds sets as a priori and also have the expert panel rate the final programme. This is in line with a paper discussing the manner in which a Delphi should be executed in health care (Trevelyan & Robinson, 2015).

4.9 CONCLUSION

The Delphi study involved two sequential rounds of online questionnaires sent via email to the experts in the field of sports physiotherapy to refine an evidence based exercise programme addressing the identified biomechanical risk factors. The Delphi process is not without its shortcomings and limitations which were described and discussed in Subsection 4.7 above.

From the draft list of exercises in Chapter 2 exercises were selected suited to address the biomechanical factors found to be associated to shoulder pain in Chapter 3. In Chapter 4, these exercises were refined and a programme suited to address the biomechanical factors associated to shoulder pain was developed. This programme needs to be tested for its effectiveness in addressing these biomechanical factors in order to be tested for its ability to prevent shoulder pain in amateur fast bowlers and overhead athletes alike. A summary of the entirety of the study and the effect of each study on the combined project can be seen in Chapter 6 (Figure 6.1).

CHAPTER 5: STUDY 3, THE EFFECTIVENESS OF A SHOULDER EXERCISE PROGRAMME, A SIX-WEEK PRE-TEST POST-TEST STUDY

5.1 INTRODUCTION

In Chapter 3 the incidence of and the biomechanical factors associated with shoulder pain in South African amateur fast bowlers were described. The incidence of shoulder pain in amateur fast bowlers (percentage of fast bowlers who sustained shoulder pain in the 2018/19 season) was determined at 23.1%. The results from the current study have indicated, through the usage of effect size calculations that the associated factors to shoulder pain are a decrease in IR ROM, an increase in ER ROM, scapula dyskinesia, and decreased muscle strength of selected muscles around the GHJ, decreased endurance and upper extremity stability. These factors were consistent with the available literature regarding shoulder pain in overhead athletes (Cools et al., 2015; Pontillo et al., 2014). In Chapter 2, evidence-based exercises were described to address the most common biomechanical factors associated to shoulder pain in overhead athletes. From the list of exercises, exercises applicable to address the determined biomechanical factors associated with shoulder pain were selected to form a proposed, evidence-based exercise programme. The proposed exercise programme was then refined and validated via a modified e-Delphi and this was described in Chapter 4.

Shoulder pain is common in overhead sports such as cricket (Cools et al., 2015). Despite the lack of evidence related to the causes of shoulder pain in overhead sports, and more specifically cricket, it has been suggested that volume of overhead activity, level of play and sport-specific adaptations (such as strength and flexibility) relate to shoulder pain (Clarsen et al., 2014; Cools et al., 2015; Giles & Musa, 2008; Kibler & Safran, 2000). Even though the repetitive overhead action and sport specific adaptations of fast bowling have been suggested to be associated to shoulder pain in fast bowlers the researcher has found no research, specifically in amateur cricketers, (Chapter 2: Literature review) available regarding shoulder pain prevention programmes in this population.

Even though the burden of shoulder pain is significant in South African fast bowlers, there are no prevention strategies in place addressing the burden of shoulder pain. The modifiable biomechanical factors, described in Chapter 3, found to have been associated to shoulder pain in these fast bowlers could be addressed by an exercise programme. The aim of the current study, Study 3, was to test the exercise programme developed through the use of literature. The exercise programme was also refined and validated by a modified e-Delphi followed by a six-week pre-test post-test study design. It stands to reason that if the exercise programme addresses the modifiable biomechanical factors associated to shoulder pain, the exercise programme could be tested for use as a prevention strategy in a large scale randomised controlled trial. The biomechanical factors proven to be associated to shoulder pain commonly predispose scapula dyskinesia. Scapula dyskinesia has been described as being associated to shoulder pain (Hickey et al., 2018). In Study 3, the prevalence of scapula dyskinesia in amateur fast bowlers was determined at 67%. Exercise prescription may address the shoulder pain associated with scapula dyskinesia yet there is no evidence regarding the development of a preventative exercise programme addressing scapula dyskinesia in fast bowlers (De Mey et al., 2013).

5.2 METHODOLOGY

Once developed via literature and refined and validated via the Delphi process, the biomechanical shoulder impairment prevention exercise programme (previously described in Chapter 4) was tested for effectiveness via a pre-post-test quasi-experimental study design. The baseline biomechanical factors proven to be associated to shoulder pain identified in Study 1 was assessed using the same valid and reliable outcome measures in the current study. In the current study, Study 3, the factors were addressed via the final biomechanical shoulder impairment prevention exercise programme. The process of the cohort of testing procedures was exactly the same as described in Chapter 3, Subsection 3.7.1 with the exception of COVID-19 protocols being put in place. The description of the procedures has been repeated in the information to follow for the ease of the reader, the figures and tables that are referred to are in Chapter 3, Subsection 3.7.1.

5.2.1 Study Design

A quasi-experimental study design is a nonrandomised, pre-post intervention study used commonly in medical literature (Harris et al., 2006). This type of study design is commonly used to evaluate the benefits of a specific intervention as it aims to establish a cause-and-effect relationship with no randomization of groups (Harris et al., 2006). A pre-post-test quasi-experimental study design was therefore employed.

5.2.2 Study Setting

The selected Premier League cricket clubs' sporting facilities were not in use to prevent the transmission of COVID-19. This rendered the intended study setting unavailable for use. This is why the sporting facilities of the clubs were not used, to prevent the transmission of COVID-19 and to adhere to prescribed government regulations. In order to ensure full adherence to the COVID-19 regulations, the parking area was well ventilated and adequate social distancing was maintained. Disinfection in the form of alcohol-based hand sanitisers, was used by participants, researcher assistants and the primary researcher. The equipment used during the execution of the data collection was sterilised with an alcohol-based cleaning agent between participants.

5.2.3 Source of Participants

Cricket South Africa and the Northern Cricket Union were approached prior to the commencement of the study. Permission was obtained to recruit a Premier League cricket squad for Study 3. Permission was granted by both of the cricketing authorities governing the Premier League cricketers (Appendix: A). The main focus of the study at large is shoulder injuries in amateur fast bowlers although all player roles from one Premier League squad were invited to partake in Study 3. The exercise programme set out to address the biomechanical factors proven to have been associated to shoulder pain in Study 1 involved only fast bowlers due to the limited research available on shoulder injuries in this population. However, considering the fact that players were assessed before and after the study period in Study 3, players acted as their own controls. The current study executed preliminary testing of the effectiveness of the exercise programme in addressing the biomechanical factors found to be associated to shoulder pain. All cricket players perform overhead roles such as throwing and bowling and the exercise programme had been shown in the available literature to effectively address the commonly associated biomechanical impairments related to shoulder pain (Chapter 2). The participants being all cricket players from one Premier League Cricket team should therefore not affect the testing of the effectiveness of the exercise programme. It should also be noted that in the selected sample 60% of the participants were fast bowlers and all of the participants performed overhead activity as part of playing cricket. Therefore, a convenience sample of one Premier League cricket team was then contacted and invited. The agreeing Premier League cricketing squad was then contacted to set up a meeting to obtain consent and execute the pre-testing procedure.

5.2.4 Study Population

The study population size was estimated to be approximately 144 amateur cricketers in the Northern Cricket Union Premier Cricket League study sample size was set to be restricted to the approximately 22 amateur cricketers from the invited Premier League cricket team squad. From the invited 22 Amateur cricketers only 18 consented to partake in the current study.

5.2.5 Inclusion Criteria

The inclusion criteria were amateur cricketers, 18 years or older, who were injury free and played at the Premier League level of club cricket in the Northern Gauteng region at the time of the conduction of the study.

5.2.6 Exclusion Criteria

Players were excluded if they were excluded from selection to the team due to an injury; and/or who have undergone any surgery to the shoulder; and/or who have presented with any progressive musculoskeletal disease.

5.2.7 Instrumentation and Outcome Measures

The outcomes measures used in the execution of the study these were the same outcomes measures used at the baseline testing of Study 1 whilst taking the regulations of COVID-19 into account. A summary of the outcomes measures is illustrated in Figure 3.3. Chapter 3, Figure 3.3 illustrates a summary of the outcomes measures used in this study. Table 3.1 has a summary of all the reliability and validity values of the outcomes measures used in the current study. The Hitech Therapy™ ten-inch goniometer (Figure 3.1) was used to measure shoulder internal and ER range of motion. Specific tests applicable to shoulder pain and scapula dyskinesia were employed at the pre- and post-testing sessions. Isometric strength was assessed using a handheld dynamometer (Figure 3.2) (Hoggan Micro Fet®).

5.3 Ethical and Legal Considerations

Prior to the conduction of Study 3, ethical and legal pre-requisites were accounted for as Physiotherapy Department, Faculty of Health Sciences and Human Research Ethics Committee (Medical) approval (Appendix: C) was obtained (number: M180410).

If willing to participate, each cricketer signed an informed consent form (Appendix: E), prior to the onset of the current study. All important facts regarding the procedures and what would be expected from the cricketers regarding the evaluation and rehabilitation programme were explained and provided in writing, before consent was obtained. The expectations of the cricketer and the process of the study was explained in layman’s terms to ensure that all the cricketers would know exactly what was expected from them.

The confidentiality of the amateur cricketers was protected throughout the study by removing any personal or identifying information from all forms of the dissemination of the data. The data will be stored on password protected laptop for at least fifteen years. All members of the sample were given the opportunity to not participate or leave the study at any point.

The participating cricketers were all given ample opportunity for questions at the pre-testing session as well given the primary researchers contact details thereby exercising the principle of autonomy. All minors were excluded from the study

5.4 PREPARATORY PROCEDURES

5.4.1 Research Assistant Training

A pilot study was conducted with the aim of training the research assistants and recreating the data collection procedure for Study 1 (Subsection 3.6.1). During this pilot study the research assistants were trained on the execution of the baseline testing procedure of Study 1 which was the same testing procedure (as well as cohort of tests) used in the current study (Study 3). The research assistants used in Study 1 were the same as the research assistants used in Study 3. One of the research assistants was trained in the execution of the final evidence based biomechanical shoulder impairment exercise programme. The primary researcher explained the aims of the final exercise programme and demonstrated the execution of the final exercise programme. The research assistant was also required to demonstrate the exercise programme back to the primary researcher. This was repeated until a complete understanding of the technique of each exercise was achieved by the relevant research assistant. There were also minimal adaptations made to the procedure in order to observe the protocols set out by the government regarding COVID-19.

5.4.2 Participant Recruitment

Cricket South Africa and the Northern Cricket Union contacted the twelve Premier League cricket clubs regarding the study and requested contact details of the required participants. The Northern Cricket Union sent the primary researcher a list of the email addresses and contact details of each of the captains and team coaches of the 12 Premier League cricket clubs for Study 1.

In Study 1 there was one team who had a response rate higher than all of the other teams, this team also was geographically suitable for all the research assistants and had suitable facilities to cater for the current study. This team was then selected to be included in the current study, Study 3. The researcher then held a telephonic meeting with the selected teams' captain and the coach in order to: recruit cricketers for the Study 3; explain the details regarding the study; and to arrange a date and time for the testing sessions. Consent was obtained from the cricketers in writing at the pre-testing session.

5.4.3 Coronavirus Disease 2019 Protocols

The Coronavirus disease 2019 (COVID-19) is a contagious, severe, acute respiratory disease (World Health Organization, 2020). The first case was identified in Wuhan, China, in December 2019. Since then it has spread worldwide, leading to an ongoing pandemic. On the 23rd of March 2019, South Africa was placed on lockdown. The lockdown was intended to limit the spread of COVID-19. The intended start date of the current study (Study 3) was the 27th of March 2020, but due to the lockdown restrictions imposed on the country, data collection could not commence. The president of South Africa indicated that a phased easing of the lockdown restrictions would begin on the 1st of May 2020. On the 1st of June the lockdown restrictions were eased to a point at which the pre-test-post-test study could begin. COVID-19 can be spread directly or indirectly through the form of droplets and aerosols (World Health Organization, 2020). The direct route of transmission is from person to person and the indirect route of transmission is through shared spaces and objects (World Health Organization, 2020). The use of face masks, maintenance of social (i.e. physical) distancing and regular disinfection of surfaces and hands can limit the spread of COVID-19 (Wang et al., 2020). The COVID-19 precautions were applied to all the testing procedures where necessary in order to prevent the transmission of COVID-19. All of the participants and the research assistants at the pre-test-post-test testing sessions was required to answer screening questions related to COVID-19 (Tassis et al., 2020). The participants and research assistants were all asked if they had any of the following symptoms: sore throat; cough; diarrhea; fever; headache; loss of smell and or loss of taste. They were also asked if they had been in contact with any COVID-19 positive patients in the last 14 days. Participants' and research assistants' temperatures were all taken and were only allowed to participate in the data collection procedure if their temperature was equal to or less than 37.5 degrees Celsius (Tassis et al., 2020; World Health Organization, 2020). All participants and research assistants were required to wear face masks.

During the CKUEST, SDT and fatigue testing using the Borg scale a minimum distance of 1.5 meters was kept between research assistant and participant. During the range of motion measurements using the 10 inch goniometer and the isometric strength testing using the handheld dynamometer the equipment was cleaned and sanitised between tests and participants were required to face in the opposite direction of the researcher as to limit the possibility of transmission.

5.5 PRE- AND POST-TESTING PROCEDURES

The consenting club arranged times and dates for the testing sessions with the primary researcher. The testing sessions took place at a secure complex outside (well ventilated) parking lot with a very large maximum capacity (of which only 20% was used) with ample space for social distancing and conveniently located for the entire cricket team and research team. During these sessions the relevant information and informed consent (Appendices: D and E) was explained. Each participant was afforded time to ask any questions. If consent was obtained, the Premier League Cricketer was screened for COVID-19 and if the Premier League Cricketer met the inclusion criteria they proceeded to complete the pre-testing procedure.

The 2018/19 cricket season commenced on the 10th of October 2018, the baseline questionnaires of Study 1 were sent out and the baseline testing procedures were executed from the 10^{th} of September 2018 up to the commencement of the season. The weekly questionnaires were sent out weekly from the commencement of the season (10 October 2018) up until the end of the season. The incidence of and associated factors to shoulder pain was determined which justified the need for Study 2. Study 3 intended to assess the effectiveness of the evidence based biomechanical shoulder impairment exercise programme with the intention of using the programme to prevent shoulder pain in future studies and clinical settings.

The season commenced later than usual and the teams did not all resume activity at the same point.

This resulted in Study 2 starting later. Study 2 also had a slow response rate which in combination with the later commencement of the 2018/19 season resulted in Study 3 being postponed to the end of March 2020 which was when the lockdown imposed on the country was initiated. Study 3 only commenced in June 2020. On the 6th of June 2020 the Premier League cricket team invited to participate in the current study attended the pre-testing session. Consent was obtained and the refined exercise programme and logbook was also explained and distributed on this day. Six weeks later the participants returned for a repeat of the post-testing procedure which was exactly the same as the pre-testing procedure. Logbooks were collected and the data was analysed and summarised.

5.5.1 Pre- and Post-Testing Procedures

The primary researcher and the same five research assistants (from Study 1) performed the tests in the same order to ensure that tests are performed in a standardised manner and order. The screening consisted of testing: shoulder IR and ER ROM at 90° shoulder abduction; weighted and non-weight SDT isometric strength by a handheld dynamometer for shoulder ER and IR at 90° of abduction; protraction of the scapula with the arm at 90° of forward flexion in supine; abduction in sitting at 45°; fatigue testing in two positions (scaption and prone-Y); and the CKUEST. This was the same procedure followed in Subsection 3.7.2. The information is repeated for flow of the methodology and the figures are available in Subsection 3.5.2. The participants were divided into four groups and were allocated time slots, further limiting large numbers at the testing procedure. The participants warmed up by prior to the commencement of the testing procedure. The warm-up performed was led by the team captain and included a five minute slow jog followed by the usual stretching and warm-up exercise performed field side before a match or training session. After the warm-up session the groups of participants proceeded to commence the testing procedure.

**It is important to note that the research assistants were blinded to the results from the pre-testing session at the post-testing session thereby limiting bias. The research* *assistant prescribing the exercise programme was also not involved in the testing procedures.*

5.5.2 Internal- and External Rotation Range of Motion

The passive ROM of glenohumeral IR and ER was measured in side lying (Figure 3.4) (Kolber & Hanney, 2012). Each cricketer was positioned in side-lying on a plinth. The arm being tested was placed in abduction and horizontal flexion with the weight of the torso of the fast bowler maintaining the alignment of the humerus while rotation was measured. The centre point of the goniometer was the olecranon process of the elbow. The stationary arm was placed parallel to the humerus and the moveable arm was placed parallel to forearm, pointed toward the styloid process of the wrist, Figure 3.4. The participant was instructed to actively externally rotate the GHJ at which point active ER of the GHJ was measured. The physiotherapist then applied overpressure at which point the passive ER was measured. This procedure was then followed for IR of the GHJ. The total arc rotational ROM was calculated for each shoulder by adding the IR and ER values (Wilk et al., 2011). The participant was asked to face away from the researcher during the testing procedure and the goniometer was disinfected with an alcohol-based sanitiser between participants.

5.5.3 Scapula Dyskinesia Test

During the execution of the SDT, the participant stood with his back towards the physiotherapist. The physiotherapist stood at least 1.5 meter away from the participant. The participant was instructed to perform bilateral abduction and then flexion of his shoulder. This movement was performed five times slowly, with controlled movement (a count of four breaths) downwards. The movement was repeated with a three kilogram weight in order to assess the degree of scapula dyskinesia when proprioceptive input (the three kilogram weight) was added.

The physiotherapist observed the motion and described it according to the procedure described by McClure and his colleagues in 2009 (McClure et al., 2009) (for both flexion and abduction). The presence of dyskinesia was described as (for both flexion and abduction):

Normal motion was described as no evidence of abnormality. Subtle abnormality was when mild or questionable evidence of abnormality was present and/or not consistently present. Obvious abnormality was noted when an obvious abnormality was indicated on three or more of five trials displayed this. The final outcome was based on combined flexion and abduction movements (McClure et al., 2009).

5.5.4 Isometric Strength Testing

Isometric strength was assessed using a handheld dynamometer (Hoggan Micro Fet®). Isometric strength testing was performed in four positions with the participants sustaining a maximum contraction for a period of five seconds (Figure 3.5). Three trials for each position were collected, with a minimum of 30-second rest between trials as 30 seconds allows for a work: rest ratio of at least 1:3 which has been shown to be an adequate amount of time needed for recovery between isometric muscle testing sessions (Blazquez et al., 2013). The participant was asked to face away from the researcher during the testing procedure and the handheld dynamometer was disinfected between the testing of participants. For specific details regarding the testing positions and the isometric strength testing, refer to Figure 3.5 and Subsection 3.7 in Chapter 3.

5.5.5 Fatigue Testing

Muscle fatigue testing was conducted in two positions: the prone-Y position and in the scaption position. Participants were asked to perform the movement of forward elevation of the GHJ in the relevant positions up to a point of fatigue using the Borg Scale. The number of repetitions were counted and recorded. The distance between participant and physiotherapist was maintained at a minimum of 1.5 meters. The equipment used was disinfected between testing procedures. For specific details regarding the fatigue testing procedures, refer to Figure 3.6 and Subsection 3.7 in Chapter Three.

5.5.6 Closed Kinetic Chain Upper Extremity Stability Test (CKUEST)

Participants performed the CKUEST by assuming a push-up position with their backs' parallel to the floor, as flat as possible, and their hands 36-inches apart (Figure 3.7: A and B). The upper extremities were positioned perpendicular to the floor and over the hands. Two lines were measured to be parallel and marked on the floor to determine the beginning placement of the hands. Participants had 15 seconds to lean over one hand, pick up the opposite hand, reach over to touch hands and return to the starting position. The distance between participant and physiotherapist was maintained at a minimum of 1.5 meters. For specific details regarding the testing positions and description, refer to Figure 3.7 and Subsection 3.7 in Chapter Three.

5.6 THE EXERCISE PROGRAMME

An exercise programme was created to address the commonly associated factors to shoulder pain by means of a literature review (Chapter 2). This exercise programme was then validated and refined by means of a Delphi study described in Chapter 4, Study 2. After each group completed the cohort of tests at the pre-testing session, the final six-week evidence based biomechanical shoulder impairment exercise programme was demonstrated by the research assistant who was trained in the execution of the final exercise programme. Each exercise was demonstrated by the primary researcher to the cohort of cricketers that made up the sample of Study 3. The final exercise programme (Chapter 4) was explained by the primary researcher to the participants of Study 3 whilst the demonstration was underway in order for the participants to understand the manner in which the exercise programme was to be performed. The exercises were also explained by the primary researcher to the participants in order to execute each exercise using the correct form. The participants were explained the dosage of each exercise and given instructions regarding the usage of the logbook (Appendix: G). The dosage of each exercise was dependant on the aim of each exercise in general and not specific to each cricket player. The exercises focussed on global stabiliser strength were instructed to be performed in dosages of two sets and 15 repetitions (Comerford & Mottram, 2001). The stretches were prescribed to be performed for sustained period of 30-seconds (Balci et al., 2019). The participants were required to perform the entire exercise programme on every alternate day of the week.

5.6.1 Exercise Programme Compliance

Exercise compliance was monitored by means of a logbook (Appendix: G) Participants were required to tick off each exercise every time it was to be performed. The programme in its entirety was required to be performed three times per week. Compliance was categorised into very compliant (exercise programme performed two times or more per week) and minimally compliant (exercises performed once or less per week). The cricketers included in the study were reminded weekly to keep performing the exercise programme and to continue using their log book.

5.6.2 Exercise Programme Feedback

Participants were asked to provide feedback regarding their perceived effect of the exercise programme in general. The responses were analysed thematically according to input given on their stability, mobility, strength and performance.

5.7 METHODOLOGICAL OVERVIEW

Figure 4.1 below illustrates a summary of Study 3's methodological procedure.

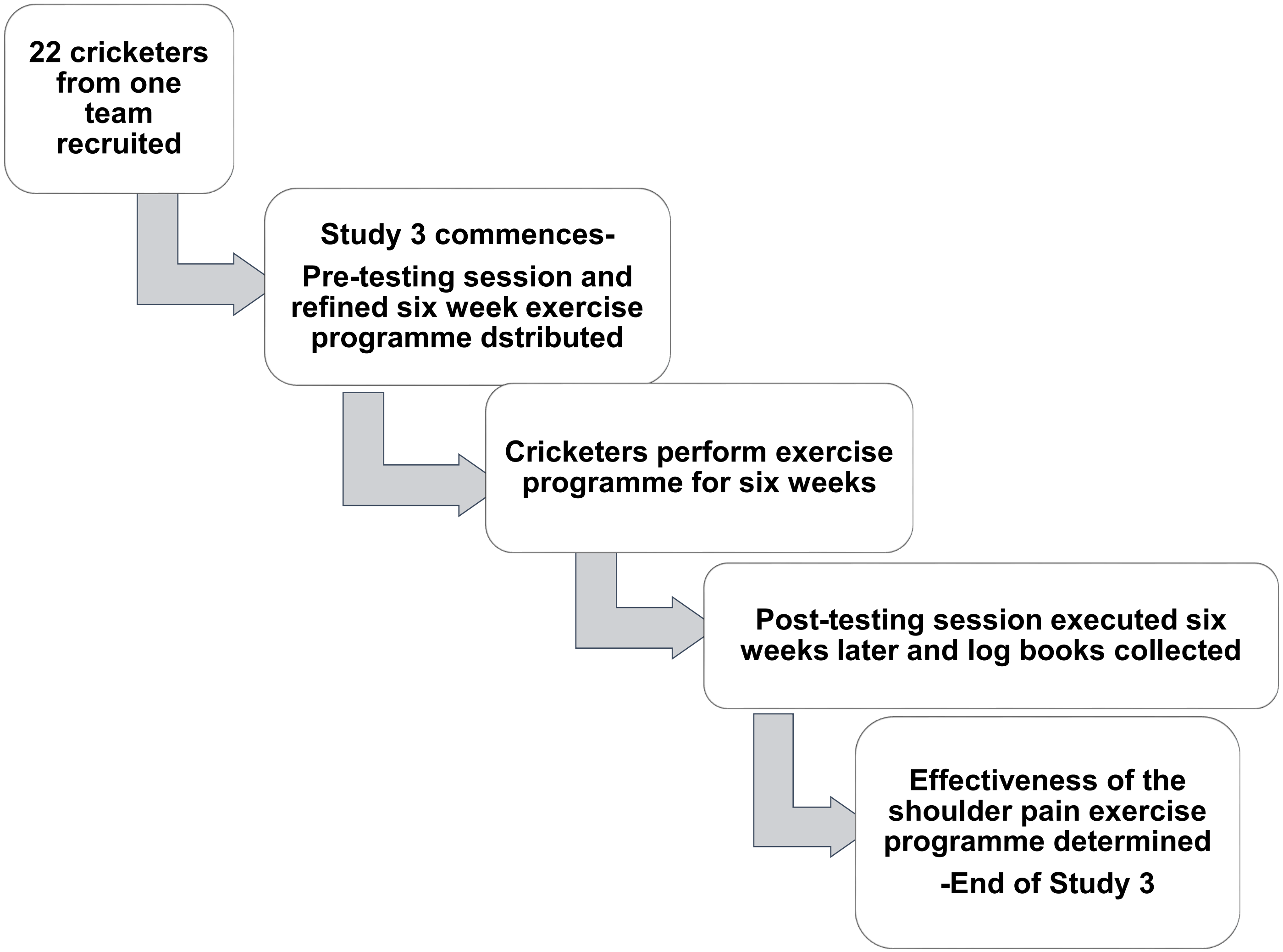


Figure 5.1: Overview of the process of the data collection procedure in Study 3

5.8 DATA ANALYSIS

As indicated in Study 3, significance testing (i.e. determining the P-value) means that the probability of the null hypothesis being rejected or not, is determined (Pautz, Olivier, & Steyn, 2018). However, this type of statistical significance does not determine or examine the importance of the relationships between the variables. In the current study the P-values are used to determine how incompatible the data are with a specific statistical model (Nahm, 2017). In the case of Study 3, the smaller the P-value the less likely the exercise programme has no effect on the biomechanical factors associated to shoulder pain.

Due to the small sample size dependent T-tests or paired sample T tests were not used to analyse the differences between the results of the continuous variables from the pre-testing session and the results of the continuous variables in the post-testing sessions. Continuous variables were analysed using a Wilcoxon signed-rank test and categorical variables were assessed by means of a McNemar’s test. Once captured, data were visually inspected for extreme values. No missing data was encountered.

5.9 RESULTS

5.9.1 Participants

Twenty-two amateur club-level cricketers (playing for the selected Premier League cricket club) were invited to partake in Study 3. Eighteen cricketers consented to and attended the pre-testing session. The player roles regarding bowling were as follows; two wicketkeepers, 13 fast bowlers (all-rounders and batters included) and three spin bowlers. Two cricketers from the pre-testing session did not attend the post-testing session due to them relocating to another province and club. This resulted in a sample of sixteen (n total =16) amateur cricketers (median weight (IQR), 76 kg (16 kg), median height (IQR), 1.8m (0.1m), median body mass index, 25.9 kg/m^2; right dominant, 14, left dominant, 2).

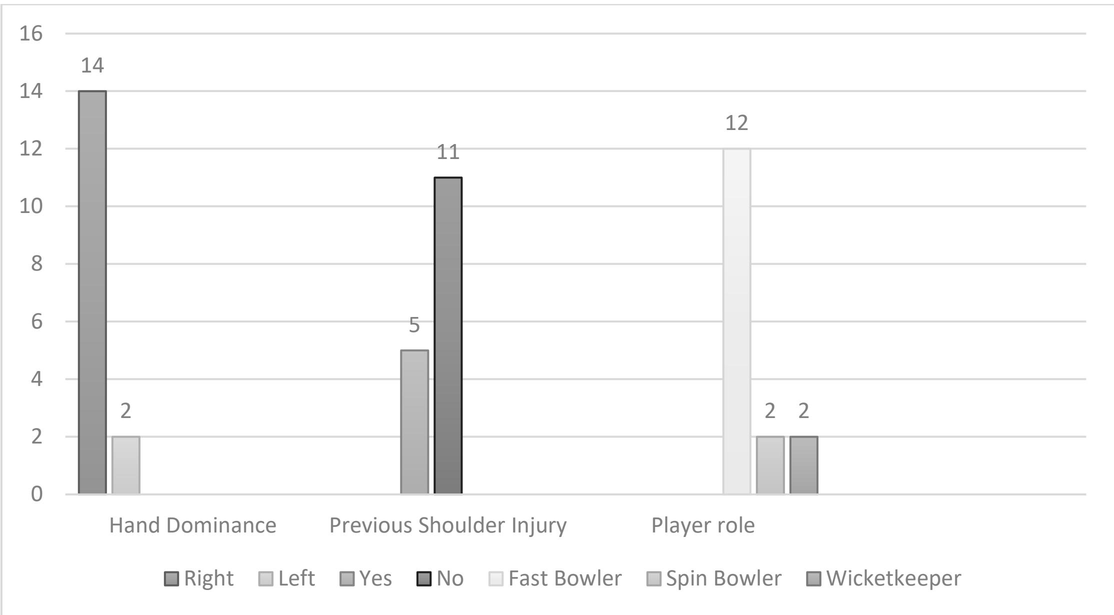


Figure 5.2: Sample demographics (n=16)

5.9.2 Compliance

Compliance was categorised as very compliant when the cricketers performed the exercises on average two or more times per week and minimally compliant when they performed the programme one time or less per week. Only 13% of the 16 cricketers were minimally compliant whilst 87% were very compliant (Figure 5.5).

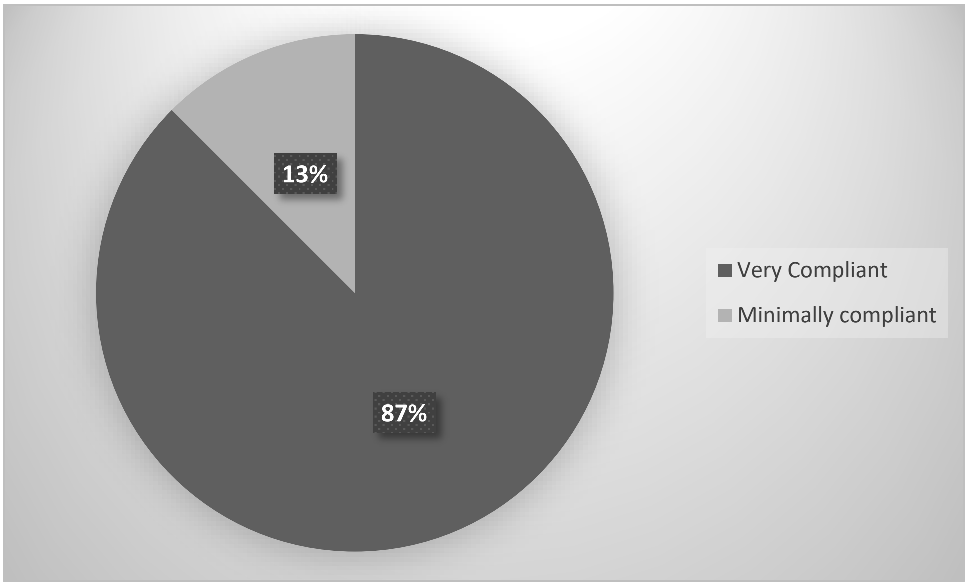


Figure 5.3: Exercise Programme Compliance.

5.9.3 Exercise Programme Feedback

The cricketers were asked to provide feedback regarding the exercise programmes effect of mobility, stability, strength and performance (Appendix: G). Five of the cricketers indicated the programme was enjoyable and that the programme felt like it increased mobility, stability, strength and increased their performance. Two of the cricketers commented that the programme increased mobility and/or decreased stiffness while one indicated that the programme increased his stability only. Two cricketers indicated that the programme was enjoyable and that it increased their strength and mobility. Four cricketers stated that they noticed no subjective improvement in their performance after executing the programme. Two cricketers labelled the exercises as being boring to perform and made no comments regarding mobility, stability, strength or performance. In summary, 31% of the cricketers indicated that the programme addressed all of the intended outcomes i.e. it increased; mobility, stability, strength and increased their bowling performance. Nineteen percent of the sample indicated that the programme addressed either strength or stiffness alone and 13% felt an improvement in both strength and mobility. Twenty-five percent of the sample indicated no difference in the intended outcomes and 12% did not comment on the perceived effectiveness of the exercise programme.

This indicates that 63% of the sample population described a positive subjective change in the intended outcomes to the exercise programme. The exercise programme had no intent on addressing or treating shoulder pain but ultimately the exercise programme was aimed at preventing shoulder pain. Taking the aforementioned statement into account, at the pre-testing session one cricketer indicated that he felt pain in his shoulder which was intermittent and not present at the baseline testing session. The feedback given was that the pain subsided and that there was no reproduction of symptoms during the usual activities eliciting pain in his shoulder such as overhead weightlifting. The possibility of assessing the exercise programmes' effect on shoulder pain (in cricketers of all player roles and other overhead athletes) in future studies is discussed further in Subsection 5.11.

5.10 THE EFFECTIVENESS OF THE EXERCISE PROGRAMME.

Each of the variables were analysed according to whether they were continuous or categorical. Continuous variables were analysed using a Wilcoxon signed-rank test and categorical variables were assesses by means of a Mcnemar's test.

Table 5.1: The differences between the pre-test and the post-test in terms of the continuous variables (n=16).

Paired variable	Pre-test Median (IQR)	Post-test Median (IQR)	95 % Confidence Interval of the Difference		Wilcoxon Signed-Rank Test (P)
			Lower	Upper	
Closed kinetic upper extremity stability test NO	16.0 (2.8)	21.5 (5.8)	-7.0	-4.0	<.001
Closed kinetic upper extremity stability test NS	9.1 (1.7)	12.0 (3.1)	-4.0	-2.2	<.001
Closed kinetic upper extremity stability test POW	62.0 (17.4)	18.4 (4.2)	-26.3	-13.2	<.001
Isometric strength testing of RC L	14.9 (4.1)	17.7 (2.4)	-4.1	-2.2	.01
Isometric strength testing of R	14.8 (4.2)	17.4 (2.2)	-3.9	-1.4	.01
Isometric strength testing of MR L	14.6 (3.5)	17.9 (3.4)	-6.0	-0.6	.002
Isometric strength testing of MR R	14.6 (3.5)	24.8 (7.8)	-5.5	-2.2	<.001
Isometric strength testing of DELT L	23.4 (4.7)	16.0 (5.9)	-0.9	3.6	.06

Isometric strength testing of DELT R	25.9 (6.0)	20.6 (8.9)	-1.3	1.9	.001
Isometric strength testing of RHOM L	16.4 (4.3)	20.6 (6.8)	-5.5	-0.8	.02
IST RHOM R	16.3 (4.9)	32.9 (8.1)	-4.7	1.4	<.001
Isometric strength testing of SA R	37.4 (4.8)	32.5 (8.0)	1.7	8.7	.01
Isometric strength testing of SA L	34.8 (7.9)	32.8 (8.9)	-0.9	7.6	.13
PASS ER	87.0 (16.8)	79 (26.3)	2.2	12.5	.01
PASS IR	44.5 (20.8)	59.5 (15.5)	-20.0	-5.0	.02
ARC PASS	130.5 (28.8)	88.5 (80.5)	-16.5	9.9	.02
ACT ER	80.5 (13.0)	71.0 (28.8)	2.1	18.3	.03
ACT IR	38.5 (20.3)	52.0 (10.5)	-21.1	-2.8	.02
ND PASS ER	81.0 (21.3)	78 (21.5)	-2.2	7.7	.15
ND PASS IR	52.0 (21.8)	57.5 (22.0)	-13.0	-0.2	.04
ND PASS ARC	121.5 (33.5)	141.0 (23.8)	-33.7	1.6	.07
ND ACT ER	74.5 (19.0)	70.0 (21.5)	-4.3	7.7	.45
ND ACT IR	45.5 (23.0)	48.5 (21.8)	-11.3	3.1	.16
ND ACT ARC	112.0 (31.8)	119.0 (22.0)	-30.5	-0.8	.15
Borg scale Scaption	15.5 (9.8)	29.0 (9.8)	-17.7	-7.6	<.001
Borg scale Y	6.0 (4.0)	8.5 (8.3)	-6.8	-2.1	<.001

*Abbreviations: NO (number of touches), PO (power score), RC (rotator cuff), R (right), L (left), MR (medial rotation), D (deltoid), SA (serratus anterior), RHOM (rhomboid), ND (non-dominant), PASS (passive), ER (external rotation), IR (internal rotation), ACT (active ROM), IQR (Interquartile range).

Table 5.2: The differences between the pre-test and the post-test in terms of the categorical variables (n=16).

Paired variable	Pre-test Mean (SD)	Post-test Mean (SD)	Mcnemar's Test (P)
Scapula dyskinesia test W FL	0.2 (0.4)	0.9 (0.3)	.01
Scapula dyskinesia test W ABD	0.3 (0.5)	0.9 (0.3)	.04
Scapula dyskinesia test FL	0.4 (0.5)	0.9 (0.3)	.02
Scapula dyskinesia test ABD	0.2 (0.4)	0.9 (0.3)	.01
Scapula dyskinesia test TOT	0.1 (0.3)	0.9 (0.3)	<.001

*Abbreviations: SDT (scapula dyskinesia test), W (weighted), SH (shoulder), FL (flexion), ABD (abduction), TOT (total)

The continuous variables were documented, in Table 5.1, with regards to median IQR and significance testing. The categorical variables, specifically the variables relevant to the SDT were presented in Table 5.2. The Wilcoxon signed-rank test indicated improvements in all of the continuous variables except in the cases of; isometric strength of the deltoid and the rhomboid muscles as well as the ER ROM and total arc ROM. There were differences indicated in the results from the significance testing of the categorical variables i.e., the results from all the positions of the SDT. Figure 5.6 below displays the significant difference between the prevalence of scapula dyskinesia in pre-test and the post-test variables.

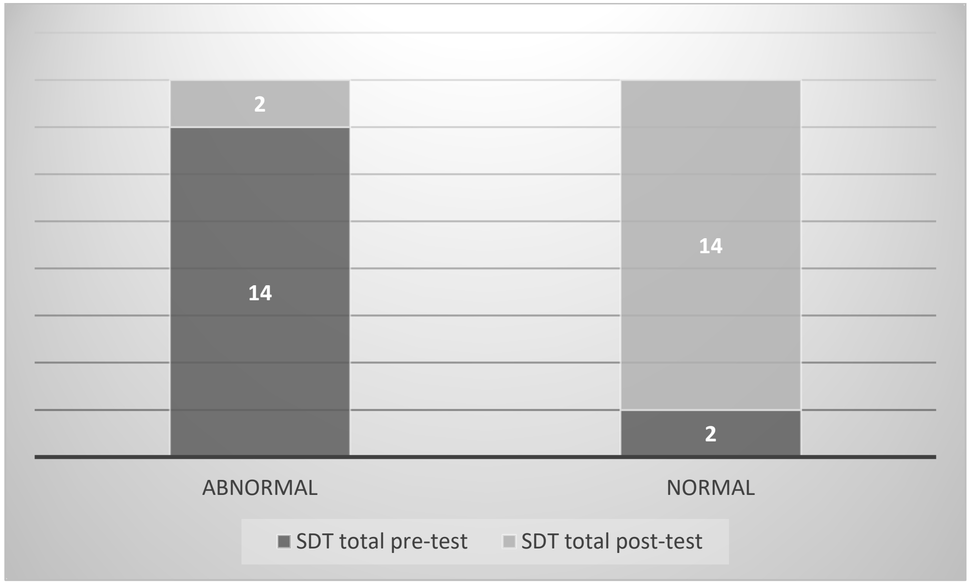


Figure 5.4: The prevalence of scapula dyskinesia, before and after

5.11 DISCUSSION

In this section the results from the current study, Study 3 will be discussed with reference to previous literature and implications regarding the effectiveness of the programme on future studies as well as shoulder pain and injury prevention.

5.11.1 The Exercise Programme Compliance

An entire amateur cricket team was invited to participate in a quasi-experimental pre-test post-test study. Eighteen cricketers consented to participate in the study and attended the pre-season testing session. These 18 amateur cricketers were then given an exercise programme to address the biomechanical factors associated to shoulder pain. This exercise programme was required to be performed three times per week and the compliance was tracked by means of a logbook (Appendix: G). Two of the 18 cricketers dropped out of the study due to the fact that they relocated to another province and their respective player level would possibly change. The restrictions due to the COVID-19 regulations did not permit them to travel back just for the post-test session adding to the removal of these two cricketers from the sample. Sixteen of the 18 cricketers attended the post-testing session and provided feedback regarding the effectiveness and compliance of the exercise programme. This limited the sample further leading to data analysis adaptations.

Compliance to the exercise programme was rated as minimally compliant and very compliant. The cricketers who performed the exercise programme twice or more per week were grouped in the category of “very compliant” while cricketers who completed the exercise programme once or less per week were grouped in the category of “minimally compliant. The compliance rate of the current study was excellent and 87% of the cricketers were very compliant while 13% of the cricketers were minimally compliant. This was suspected to have been due to the constant communication in the form of email and text message reminders. The two cricketers who were minimally compliant had ignored communication from the primary researcher. This is comparable with the results of a previous study indicating that booklets (such as the logbook provided in the current study) do not increase compliance rates regarding exercise programmes (Van Reijen, Vriend, Zuidema, Van Mechelen, & Verhagen, 2016). It is important to note that the results from the current study indicated a much higher compliance rate. The higher than usual compliance rate observed in the current study can be due to the fact that the relatively small sample in the current study simplified the communication and tracking process between the primary researcher and the participants. Due to the small sample size and high compliance rate the results were not analysed with compliance as a confounding factor as only two participants were minimally compliant. Although, with regards to the exercise programme feedback it was possible to describe the differences in the feedback between the two categories of compliance.

5.11.2 Participant Responses to the Exercise Programme

Participants were required to provide feedback regarding the execution of the exercise programme. The feedback was categorised regarding the intended outcomes i.e. mobility, stability, strength and performance. In terms of negative feedback only 25% felt no difference after the execution of the exercise programme for six weeks, of whom two (12.5%) of the cricketers had a minimal compliance to the exercise programme. The lack of consistency in performing the exercise programme could justify the lack of the perception of improvement in the two cricketers and therefore from the four cricketers who indicated no subjective change in the intended outcomes, only two cricketers (who complied to the intended dosages of the exercise programme) felt no subjective change by performing the exercise programme for six weeks. One of the cricketers presented with chronic shoulder pain which was intermittent (not present at the time of the pre-test or post-test sessions). This cricketer indicated that after the six weeks of performing the exercise programme every alternate day, the cricketer had no shoulder pain. This however was not an aim of the current study although is consistent with findings from literature that exercise programmes can decrease shoulder pain and disability (Curtis et al., 1999; Mohamed, Jan, El Sayed, Wanis, & Yamany, 2020). Exercises have been proven to address and prevent pain in overhead athletes and this information will be discussed in the relevant subsection regarding the recommendations for future studies (Cools et al., 2007).

5.12 THE EFFECTIVENESS OF THE EXERCISE PROGRAMME

The effectiveness of the final evidence based biomechanical shoulder impairment exercise programme was tested by means of paired Wilcoxin signed-rank tests (continuous variables) and Mcnemar's tests (categorical variables).

Glenohumeral joint rotational ROM, isometric muscle strength, scapula dyskinesia, upper extremity stability and endurance all displayed differences between the outcomes observed in the pre-test and the post-test. Interpreting the P-value has been frequently critiqued in the latest literature and many researchers inaccurately use the P-value to measure the significance of difference between two groups. In the current study the higher P-values indicated that the final exercise programme possessed small or little compatibility with having an effect on the referred to impairment and the smaller P-values indicated the reverse (Nahm, 2017).

5.12.1 Glenohumeral Internal and external rotation ROM

The habitual positioning of the GHJ, in excessive ER during bowling, while not allowing the full range of IR ROM, may lead to GIRD and an increase in ER range of motion (Comerford & Mottram, 2001). This is similar to the results of Study 1 therefore, addressing the decreased IR ROM and increased ER ROM may prevent and/or decrease shoulder pain.

Passive and active recordings of shoulder rotational ROM was measured using a 10-inch goniometer. The active and passive ROM values were then combined to provide the passive and active total arc ROM. The total arc ROM of both arms, measured both actively and passively, as well as the non-dominant shoulder ER and IR ROM measurements were not consistently different when comparing the pre-test and post-test values. This is understandable as the non-dominant shoulder is rarely limited in overhead athletes with regards to shoulder rotation ROM and therefore would leave less room for improvement (Giles & Musa, 2008; Seabra, Van Eck, Sá, & Torres, 2017; Sundaram, Bhargava, et al., 2012). The ER decreased whilst the IR significantly increased with consistent positive changes in ROM therefore the total ROM remained relatively the same, this would explain an insignificant change in the total arc ROM. IR ROM in the dominant shoulder increased significantly in the post-testing session with a difference in the median of 15 degrees (P=0.02). In Chapter 3, a decrease in passive

IR ROM of the dominant shoulder in amateur fast bowlers was found to be associated to shoulder pain. In a systematic review investigating GIRD as a risk factor for upper extremity injury in overhead athletes it had been found that both an increase in ER ROM and the decrease in IR ROM favoured the development of injury in overhead athletes (Keller et al., 2018). The loss of internal rotation as a contributing factor to shoulder pain is consistent with the available literature where glenohumeral internal rotation deficit (GIRD) has been identified in the literature as an associative risk factor for shoulder pain in overhead athletes (Giles & Musa, 2008; McClure et al., 2009; Saccol et al., 2016).

In the current study, the results of the post-testing cohort of tests indicated that measurements of shoulder ER ROM, displayed consistent ($p=0.01$) decreases in the dominant shoulder with a decrease in the median ROM of 8.5 degrees actively. This is fitting as shoulder rotational dysfunctions, such as an increase in ER ROM and a decrease in internal rotation ROM, have been shown to contribute to chronic shoulder injuries in cricket fast bowlers and the exercise programme was effective in achieving the required rotational ROM alterations (Sundaram, Bhargava, et al., 2012). The ROM alterations would indicate that the exercise programme resulted in clinically significant increases in IR ROM of the dominant arm with consistent increases in ER ROM rendering the exercise programme effective in addressing the associated factors related to shoulder pain with regards to ROM.

5.12.2 Scapula Dyskinesia

Scapula dyskinesia was tested by means of the SDT (McClure et al., 2009). The positions of the components tested, as part of the SDT, were flexion and abduction of the GHJ as well as weighted flexion and abduction of the GHJ (McClure et al., 2009). The differences between the results of all the components of the SDT between the pre-test and post-test indicated consistent improvements in the prevalence of scapula dyskinesia. All of the components of the SDT and the total prevalence of scapula dyskinesia were all consistently improved after performing the six-week exercise programme. Figure 5.6 displays the change in the prevalence of scapula dyskinesia. At the baseline scapula dyskinesia was present in 88% of the cricketers. After the participants performed the six week exercise programme only 22% of the participants presented with scapula dyskinesia indicting that the combination of exercises in the six week exercise programme were effective in significantly decreasing the prevalence of scapula dyskinesia. Even though evidence regarding the association of scapula dyskinesia with shoulder pain in overhead athletes is inconclusive, athletes with scapula dyskinesia and shoulder pain have increased severity of symptoms and overhead athletes such as fast bowlers who present with scapula dyskinesia, are at a higher risk of developing shoulder pain and pathology (Hickey et al., 2018; Struyf et al., 2014). This is similar to the results of Study 1, Chapter Three. The exercise programme therefore, is effective in decreasing the prevalence of scapula dyskinesia.

5.12.3 Upper Extremity Strength, Stability and Endurance

In the Study 1, Chapter Three assessing amateur fast bowlers, there was indication that there is an association between decreased strength, endurance, stability and proprioception with shoulder pain in these amateur fast bowlers. This is consistent with the available literature (Pontillo et al., 2014). Upper extremity strength, stability and endurance was assessed using the cohort of tests described at the pre-test. After six weeks of performing evidence-based shoulder exercises, these variables were assessed again. The exercise programme resulted in consistent increases in upper extremity strength, stability and endurance.

5.12.3.1 Isometric Strength Testing Using a Handheld Dynamometer

Isometric muscle strength of the rotator cuff ($p=0.01$), the medial rotators ($p=0.002$ on the left and $p<0.001$ on the right) and the serratus anterior ($p=0.01$) on the right (dominant side in majority) showed consistent increases after performing the six-week evidence based shoulder exercise programme. The left deltoid ($p=0.06$) and the left (non-dominant in majority) serratus anterior ($p=0.13$) showed no significant increases in strength after performing the six week evidence based shoulder exercise programme. This could be due to the fact that none of the exercises isolated these mobilisers or movement muscles. The dominant (right) deltoid and rhomboid showed consistent increases in muscle strength and is explained by the increased global stability of the dominant shoulder combined with bowling and the exercise programme. Mobilisers are task orientated muscles that are strengthened by plyometric and concentric isolated exercises (Comerford & Mottram, 2001; Maquirriain, Ghisi, &

Kokalj, 2007; Mottram & Comerford, 2008). The six-week exercise programme did not isolate any of these mobilisers and placed focus on functional evidence based exercises substantiated by evidence to address the factors associated to shoulder pain. A deficit in strength of mobiliser muscles are rarely associated to pain and injury as it more common for these muscles to lose extensibility and result in restrictions of movement with poor quality of movement (Comerford & Mottram, 2001). The left serratus anterior did not differ significantly at the post-test session unlike the right serratus anterior. This could be due to the fact that only two of the participants were left hand dominant. Of the two left hand dominant participants one was a wicket keeper and therefore was required to perform minimal amounts of overhead activities such as throwing and bowling when compared to an all-rounder or bowler, the other left-handed participant had a player role of a top order batter who did not comply to the exercise programme. The dominant (bowling and throwing arm) would undergo biomechanical adaptations, described in Chapter 2, such as decreased strength coupled with poor positioning of the scapula, therefore, this is why it is postulated that the serratus anterior on the left did not display significant increases in strength after performing the exercise programme. Imbalances in the glenohumeral and scapulothoracic musculature strength are present in overhead athletes with shoulder pain and pathology (Cools et al., 2005; Page, 2011). The strength of the cuff and the surrounding scapula muscles should form part of a pre-season battery for amateur fast bowlers (Chapter 3, Study 1) and it stands to reason that if the muscle strength of the dynamic stabilisers (serratus anterior, rotator cuff and the medial rotators) are preventatively strengthened or maintained with regards to strength, the six week shoulder exercise programme may prevent shoulder pain in fast bowlers and overhead athletes alike.

5.12.3.2 Upper Extremity Stability and Endurance

In Chapter 3, Study 1, baseline tests have shown that fatigue, strength poor proprioception and decreased endurance of the scapula muscles are associated to the development of shoulder pain in overhead athletes (Kibler et al., 2013). The functional tests included in the cohort of the pre-testing procedures provided quantitative data regarding stability and endurance. The CKUEST quantified performance of the participant with functional information regarding the stability and endurance function of the shoulder (Tucci et al., 2014). The current study assessed the upper extremity stability and endurance of cricketers playing at an amateur level using the CKUEST and the prone-Y and scaption testing (up to fatigue using the Borg scale) positions before and after an evidence-based exercise programme aimed at addressing the factors proven to have been associated to shoulder pain (Chapter Three, Study 1). In the current study the differences in the results between the pre-test and post-test regarding the CKUEST ($p<0.001$) and fatigue testing in both the prone-Y ($p<0.001$) and scaption ($p<0.001$) testing positions were consistently increased in terms of repetitions. Excessive downward rotation or a decreased upward rotation of the scapula due to poor endurance and activation of the lower fibres of trapezius is related to shoulder pain in cricketers and overhead athletes alike (Arora et al., 2015; Struyf et al., 2014). Fatigue may negatively affect proprioception which in turn has shown to affect bowling accuracy and the positioning of the shoulder resulting in shoulder pain and/or injury (Weerakkody & Allen, 2017). The CKUEST and relevant fatigue tests indicated that the combination of exercises of the evidence-based exercise programme performed for six weeks significantly increased endurance and stability of the upper limb in the sample population and may prevent or rehabilitate shoulder pain associated with biomechanical factors in amateur cricketers.

5.13 STRENGTHS OF THE STUDY

There is limited information available regarding amateur cricketers and the majority of the information regarding cricketers of any player level are mostly relevant to the elite cricketing population who have access to fully fledged gym and medical professionals on staff.

This is the only study of its kind focussed on amateur cricketers. The effectiveness of the evidence based biomechanical shoulder impairment exercise programme was assessed using valid and reliable outcome measures. The final evidence based biomechanical shoulder impairment exercise programme (proven to be effective in addressing the biomechanical factors associated to shoulder pain) can be performed at any point and in any setting without the usage of equipment.

The compliance of the amateur cricketers to the exercise programme was monitored and documented objectively. Compliance was excellent and the study had a low attrition rate. This further strengthened the results of the study. The evidence based biomechanical shoulder impairment exercise programme effectively addresses the factors associated to shoulder pain and in turn may prevent shoulder pain. The ability of the exercise programme to prevent shoulder pain can be further assessed over a period of time in Amateur fast bowlers. Prevention is better than cure, billions are alleviated of the economic burden by means prevention strategies such as vaccines and screening cohorts (Hewett & Bates, 2017). The knowledge regarding the biomechanical tendencies associated to pain and injury has only progressed in the last 20 years.

The research assistant prescribing the programme did not perform the baseline assessments and the results from the pre-testing sessions were not available to the research assistants performing the post-testing session, this limited bias and was a another strength of the study.

Clinicians are now able to in some instances identify underlying mechanisms that may lead to injury assisting in the development of prevention strategies to noncontact musculoskeletal injuries and in turn decreasing the economic burden of sports medicine treatments and enhancing the longevity and sporting careers of sportsmen (Hewett & Bates, 2017). Even though the prevalence of shoulder pain is high in cricketers and more specifically fast bowlers, there is no evidence indicating efforts to prevent shoulder pain in this population (Chapter 2). This is the only study of its kind initiating preventative measures, such as an exercise programme, to noncontact shoulder pain in amateur fast bowlers.

5.14 LIMITATIONS AND FUTURE RESEARCH CONSIDERATIONS

The current study used a pre-test post-test study design and not a randomised control trial. A high quality randomised control trial is considered the best and most rigorous way of testing interventions (Barton, 2000). The reason for using a pre-test post-test study design was the usage of a small sample size available in one team due to the COVID-19 regulations, the availability of research assistants and financial constraints.

It is recommended that future studies use a randomised control trial study design with a larger number of participants to investigate the effectiveness of the exercise programme in preventing shoulder pain over a period of time in amateur fast bowlers. With the addition of a control group in a randomised control trial the validity of the results will be increased and the placebo effect of the exercise programme can be excluded. The pandemic COVID-19, inflicted many limitations including: a shortened timeline to complete the pre-post-test study with little time left before the commencement of the season which meant that the testing would end up moving into the season had the researcher have moved it any later, the availability of participants and research assistants was limited as well. The time-limit and the COVID-19 pandemic also added to the reasoning behind including one full Premier League Cricket squad instead of just amateur fast bowlers. Using one full Premier League cricket squad instead of amateur fast bowlers alone did limit the specificity of the results to just fast bowlers however the majority of the sample population in the current study were fast bowlers. With a larger sample, the proportion of left- and right hand dominant cricketers as well as player roles can be equally distributed between groups which could possibly result in more specific and generalisable results. Due to the later commencement of the pre-test post-test study the methodology began whilst pre-season training started and this could have meant that the strength of the amateur fast bowlers increased due to the increase of training in combination with the exercise programme which is a limitation. The researcher therefore recommends that future studies are either done during a season (with two groups in a randomised control trial as the addition of a control group will address the possibility of an increase in strength due to external factors) or perform the quasi-experimental study prior to the commencement of any training or matches.

The printed out logbook was a limitation in the study as it was only assessed at the end of the six week period, making it impossible to identify non-compliant participants throughout the six weeks. It is recommended that future studies use online log books in order for continuous monitoring of participant compliance. The recommended dosage for the performance of the exercise programme was three times per week. Many participants performed the exercise programme twice (per week / in total during the study) and two participants performed the exercise programme one time or less per week. Daily communication, requiring a response with adequate participant numbers, allowing the exclusion of non-compliant participants is recommended for future studies. The recommendation to improve compliance is to use online platforms so that it may be possible to have online monitoring of compliance in order to achieve the desired dosage of the exercise programme by participants in future studies. Daily communication requiring response or online logging is recommended. The larger sample size recommended for future studies will also allow researchers to analyse the effect of compliance on the outcomes tested.

Future studies can use the final exercise programme (Chapter 4) in a longitudinal cohort study testing the effectiveness of the exercise to prevent shoulder pain over a period of time, i.e. a complete cricket season. If proven effective in preventing shoulder pain in amateur cricket players in the long term it will aid in the efforts in decreasing the economic burden of musculoskeletal injuries and increasing the longevity of an overhead athlete’s career (Hewett & Bates, 2017). This study can also be applied to all forms of overhead athletes thereby testing the generalisability of the programme to all overhead sports regarding shoulder injury rehabilitation and prevention. One of the cricketers suffered from non-contact shoulder pain during the six week period of performing the exercise programme and indicated that after six weeks the pain resolved completely, the recommendation is that future studies also evaluate the effectiveness exercise programme to treat or rehabilitate non-contact shoulder pain in overhead athletes.

5.15 CONCLUSION

The six-week evidence based (Chapter 2) biomechanical shoulder impairment exercise programme addressing the biomechanical factors associated to shoulder pain in amateur fast bowlers (Chapter 3) was validated and refined by means of a modified e-Delphi study (Chapter four). This exercise programme was tested via a quasi-experimental pre-test post-test study design and proven clinically significant in addressing and decreasing ER ROM, fatigue and scapula dyskinesia. The exercise programme also increased serratus anterior muscle strength, deltoid, rotator cuff muscle strength, muscle strength of the medial rotators of the GHJ, upper limb stability, upper limb proprioception, upper limb endurance and IR ROM all of which were proven to be associated to shoulder pain when in deficit. Therefore, the proposed exercise programme, is effective in addressing the majority of factors proven to have been associated to shoulder pain in amateur fast bowlers. Future studies are recommended to; test the effectiveness of the exercise programme, using a randomised controlled study over an entire season (including long term follow ups) on a larger sample size, to prevent shoulder pain in amateur cricketers. A summary of the entirety of the study and the effect of each study on the combined project can be seen in Chapter 6 (Figure 6.1).

CHAPTER 6: THE CONCLUSION OF THE THESIS

In Chapter 1 the greater picture of the study was described in terms of the aims, objectives, problem statement and research questions. In summary, amateur fast bowlers are susceptible to shoulder pain yet there is no information regarding the incidence of or the associated factors to shoulder pain in this population. The majority of information available regarding shoulder pain in fast bowlers are related to a professional level. Exercises to prevent and treat neuro-musculoskeletal conditions may decrease the burden on global economic structures and even so there are no programmes aimed at addressing or preventing shoulder pain to lessen the burden of shoulder pain in amateur overhead athletes and fast bowlers alike.

In Chapter 2, the literature was reviewed in order to determine what is known regarding the incidence of, and associated factors to shoulder pain in amateur fast bowlers. Once it had been identified that there is a dearth of information regarding amateur fast bowlers, the researcher reviewed the literature regarding the most commonly associated factors to shoulder pain in overhead athletes and fast bowlers alike. Once these factors were identified, an evidence-based selection of exercises were described in terms of each of the commonly associated biomechanical factors to shoulder pain in overhead athletes and fast bowlers alike.

After a thorough review of the available information, it was found that even though the prevalence and incidence of shoulder pain is high in overhead athletes and elite fast bowlers alike, there is no available information regarding the incidence of or the associated factors (an increase in ER ROM and muscle strength of selected muscles around the GHJ, endurance and upper extremity stability) to shoulder pain in amateur fast bowlers. In addition to this, scapula dyskinesia has been identified as a related factor to shoulder pain and the prevalence of it is unknown in the aforementioned population. There is also no available evidence-based and scientifically tested exercise programmes aimed at preventing shoulder pain or the associated factors to shoulder pain in the current population.

The primary researcher of the current study aimed to address the aforementioned gaps in the knowledge in terms of shoulder pain in amateur fast bowlers by:

- Determining the incidence of shoulder pain in amateur fast bowlers (Chapter 3, Study 1)
- Determining the prevalence of scapula dyskinesia in amateur fast bowlers (Chapter 3, Study 1).
- Determining the most commonly associated biomechanical factors associated to shoulder pain in amateur fast bowlers (Chapter 3, Study 1).
- Developing an evidence based biomechanical impairment shoulder exercise programme (Chapter 2) and refined and validated this programme by means of a modified e-Delphi technique (Chapter 4, Study 2) to prevent shoulder pain in amateur fast bowlers.
- Testing the ability of the evidence-based biomechanical impairment shoulder exercise programme to address the associated biomechanical dysfunction related to shoulder pain in amateur cricketers (Chapter 5, Study 3).

All of the aims listed above were achieved. In Study 1 (Chapter 3) (a longitudinal cohort study) the incidence of and associated factors to shoulder pain were determined. The seasonal incidence of shoulder pain in amateur fast bowlers is recorded at 23.1% (percentage of amateur fast bowlers who have sustained shoulder pain during an entire season). The associated factors to shoulder pain, calculated by means of effect sizes, were determined as; a decrease in GHJ IR ROM, an increase in GHJ ER ROM, decreased endurance of the surrounding scapula muscles, poor proprioception, and scapula dyskinesia and decreased dynamic stability of the shoulder complex.

An exercise programme was developed using the available literature in Chapter 2, this exercise programme was then refined and validated by means of a modified e-Delphi described in Study 2 (Chapter 4). The exercise programme included the following exercises; the scapula retraction exercise (superman-T), the scapula wall slide, the scapula depression exercise (superman-Y), an eccentric rotator cuff exercise, the sleeper stretch and the unilateral corner stretch. The exercise programme was then tested by means of a six-week pre-test post-test quasi-experimental study design

(Chapter 5, Study 3). After performing the six-week exercise programme increases in internal rotation ROM, dynamic stability around the shoulder complex, strength of the surrounding scapula muscles and endurance were noted. In addition to the above, shoulder external rotation ROM and the prevalence of scapula dyskinesia decreased significantly as well. The programme was proven effective in terms of addressing the most common biomechanical factors associated to shoulder pain in amateur fast bowlers.

In conclusion the seasonal incidence of shoulder pain expressed as a percentage of amateur fast bowlers experiencing shoulder pain is 23.1%. The prevalence of scapula dyskinesia in amateur fast bowlers is 67%. The factors proven to be associated to the development of shoulder pain in amateur fast bowlers have been identified. These factors were then effectively addressed by an exercise programme developed and refined using evidence and a modified e-Delphi process. The recommendations of Studies 1 to 3 are described in detail in their relevant subsections within their relevant chapters and summarised in conclusion.

All the aims and objectives set out by the researcher in Chapter 1 were achieved. From the results obtained in Study 1, it is evident that the prevalence of shoulder injuries in amateur cricket players is higher than previously reported. The implementation of the evidence based biomechanical shoulder impairment exercise programme developed in Study 2 and assessed for effectiveness in Study 3, has the potential to address predisposing factors to shoulder injury and is recommended for use as a preventative strategy for amateur fast bowlers.

Figure 6.1, below, provides an overview of the current study in general (Studies 1-3 combined)

Aim of Study 1: To determine the incidence of and the associated factors to shoulder pain in amateur fast bowlers.

The incidence of shoulder pain determined via a longitudinal cohort study (Study 1) (23.1%).	Associated factors to shoulder pain determined (Study 1) (effect sizes): decreased internal rotation ROM (0.6); increased external rotation ROM (effect size=1.0); poor endurance (effect size= 0.5) and isometric muscle strength of selected muscles (0.3 - 0.5).

Aim of Study 2: To develop, validate and refine an evidence-based biomechanical shoulder impairment exercise programme.

Evidence based exercise programme developed using the available evidence in Chapter 2.	Evidence based exercise programme refined and validated via a modified e-Delphi in Chapter 4. The final exercise programme can be found in table 4.21, Chapter 4.

Aim of Study 3: To assess the effectiviness of the evidence based biomechanical shoulder impairment exercise programme over six weeks.

Pre-testing done in order to establish baseline values regarding the associated factors to shoulder pain. Exercise programme prescribed for six weeks (Chapter 5).	The effectiveness of the exercise programme was determined after cricketers performed the exercise programme for six weeks then underwent the baseline testing procedure again at the post-testing session (Chapter 5). The Glenohumeral joint rotational ROM, isometric muscle strength, scapula dyskinesia, upper extremity stability and endurance all displayed differences between the outcomes observed in the pre-test and the post-test.

Figure 6.1: An overview of the thesis

6.1 STRENGTHS OF THE STUDY

The strengths of the current study are described under the relevant subheadings in Chapters 3, 4 and 5, respectively. The strengths of this thesis are summarised below:

6.1.1 Strengths of each study in summary

1. The longitudinal cohort design of Study 1 is a strength of this study in this population as this is the first of its kind in amateur fast bowlers.

2. The baseline screening procedures executed in Study 1 all had good reliability and validity values adding quality control and assurance to the values obtained.

3. The effectiveness of the final evidence based biomechanical shoulder impairment exercise programme was assessed using the same valid and reliable outcome measures executed in the baseline testing session of Study 1.

4. A major strength of the current study and the developed and tested final evidence based biomechanical shoulder impairment exercise programme is that it can be performed at any point and in any setting without the usage of equipment.

5. The bias was limited in Study 3 by assuring that the research assistant prescribing the programme did not perform the baseline assessments and the results from the pre-testing sessions were not available to the research assistants performing the post-testing session. This was a further strength of the current study.

6. This is the only study of its kind initiating preventative measures, such as an exercise programme, to shoulder pain in amateur fast bowlers.

6.1.2 The strengths of the study overall – a birds eye view

The thesis first explored the literature in a systematic manner determining what is known and not known regarding the incidence and prevalence of shoulder pain in amateur fast bowlers. The factors indicated to be commonly associated to shoulder pain in overhead athletes, in general, were used to create an evidence based group of exercises forming the basis of the exercise programme before the modified e-Delphi was executed. During the modified e-Delphi various experts were involved in the refinement and validation of the final evidence-based biomechanical shoulder impairment exercise programme. Due to various experts contributing to the current study as well as literature being the basis of all outcomes of the current study, the validity and quality of the final evidence-based biomechanical shoulder impairment exercise programme was increased. The current study as a whole followed a rarely studied population from determining the incidence and prevalence of shoulder pain in amateur fast bowlers right up to a point of developing a possible prevention strategy. It opens up revenues of thought into future studies related to this population and the health condition (shoulder pain in amateur fast bowlers) as well as overhead athletes at large.

6.2 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE STUDIES - A SUMMARY

The limitations of the current study and the relevant recommendations for future studies (described in detail under the relevant subheadings of Studies 1-3); are summarized below.

1. The study was limited as small numbers of participants were available to participate due to the nature of amateur sport and the COVID-19 pandemic. This meant that the ability of the final exercise programme to address shoulder pain in amateur fast bowlers was not assessed. In Chapter 5, one participant expressed a significant decrease in his symptoms of shoulder pain. The recommendation of the current study is to prescribe exercises from the final

exercise programme to patients presenting with pain related to the relevant associated factors to shoulder pain described in Chapter 3. Thereafter, by means of a randomised control trial, assessing its effectiveness to address the shoulder pain associated to these factors.

2. The study was limited to amateur fast bowlers from one league in one province in South Africa. The authors recommend future studies initiate further incidence and prevalence studies in terms of shoulder pain in amateur fast bowlers including larger numbers of fast bowlers from different provinces in order to execute regression analysis to investigate the predictive validity of the cohort of baseline tests used in the current study as well as generalise the results to the amateur fast bowling population.

3. The 2018/19 cricket season followed a complicated schedule allowing for discrepancies in time-lines of the commencement of matches between teams. This coupled with the non-timeous responses by the amateur fast bowlers limited the current studies' ability to investigate bowling technique and workload for association to shoulder pain in amateur fast bowlers. It is therefore recommended by the current study that future studies investigate: the relationship between bowling technique and training workload to the development of shoulder pain in amateur fast bowlers, to test the associated factors for correlations with bowling technique and performance in fast bowlers, and to investigate the influence of these associated factors to pace, performance and accuracy.

4. Due to time constraints, the availability of participants and the current COVID-19 pandemic the current study employed a quasi-experimental pre-test post-test design to assess the effectiveness of the evidence-based biomechanical shoulder impairment exercise programme. The current study recommends that future studies test the developed exercise programme using randomised control study design and consider using longitudinal study designs in order to determine the long term effect of the exercise programme on the development of shoulder pain in amateur fast bowlers.

5. To investigate the ability of the exercise programme to prevent shoulder pain (taking the limitations and recommendations listed above into account) in various levels of fast bowlers and overhead athletes alike.

6.3 CLINICAL RECOMMENDATIONS - A SUMMARY

The results of the current study (overall) lead to the following summary of recommendations to clinical and sports physiotherapy settings:

1. The baseline testing procedure executed in Chapter 3 is recommended to be applied in the pre-season screening regimen of a fast bowler and overhead athlete alike.

2. Amateur cricket teams are recommended to apply the final exercise programme to fast bowlers' training regimes in order to decrease the prevalence of the associated factors to shoulder pain in fast bowlers.

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APPENDIX A - LETTERS OF PERMISSION

Cricket South Africa (NPC)
86, 5th Street, Melrose Estate, 2196
PO Box 55009, Northlands, 2116
Tel: +27 (0)11 880 2810
Fax: +27 (0)11 880 6578
Website: www.cricket.co.za

14 June 2018

To whom it may concern

RE: ““Shoulder pain in South African Premier League fast bowlers: Prevalence, incidence predictive factors and prevention”?

The protocol for the research project mentioned above has been submitted to the CSA Research committee by Muhammad Dawood and Prof Benita Olivier. The CSA research committee approves the study and provides permission for the study to be conducted using the participants as outlined in the research protocol.

Yours sincerely

Dr Janine Gray
Chairperson of the CSA Research Committee


CRICKET
SOUTH AFRICA
DR JANINE GRAY
CSA Research Consultant
janineg@cricket.co.za
D: +27 (0) 21 650 4557
F: +27 (0) 21 650 1796
M: +27 (0) 82 498 3178
www.cricket.co.za

Permission to Use the Photographs In Study 1 And Study 3

I hereby give permission that the authors of this study can use photographs of myself as visual demonstrations in their article and thesis publications.

Participant 1

Name and surname: Henriko Collins

Place signed: Pretoria

Date: 15/10/2020

X

Participant 2

Name and surname: Charlene Engelbrecht

Place signed: Pretoria

Date: 15/10/2020

Permission to Use the Photographs In Study 2 (Exercise programme photographs)

SEFAKO MAKGATHO
HEALTH SCIENCES UNIVERSITY

PHOTO CONSENT FORM

I, Delton Khosa consent to Muhammad Dawood using my photographs in his PHD dissertation. This include all work emanating from the dissertation, for any legal use, including but not limited to: publicity, copyright purposes, illustration, advertising, and web content.

Furthermore, I understand that no royalty, fee, or other compensation shall become payable to me by reason of such use.

Photographs Owner Signature: DKhosa ____________________ Date: 19-04-2021

APPENDIX B - QUESTIONNAIRES

Baseline questionnaire

Please complete the survey below.

Thank you!

Today's date	__________________
First name	__________________
Surname	__________________
Age	__________________
Are you	◯ Female? ◯ Male?
Height (cm)	__________________
Weight (kg)	__________________
BMI	__________________
Team(s) playing for	__________________
E-mail address	__________________
Cell phone number	__________________
What is your current working status? (Tick all that apply)	☐ Self Employed or Business owner ☐ Working for pay at a job or business ☐ Working, but not for pay ☐ Not Working at a job or business but looking for work ☐ Not working at a job or business and not looking for work ☐ Full Time Student ☐ Part Time Student ☐ Retired ☐ Other

Role

What is your main role in the cricket team you are mostly playing for?	◯ Pace bowler ◯ Spin bowler ◯ Batsman ◯ Wicket keeper ◯ All rounder
Which type of bowler are you?	◯ Fast pace bowler ◯ Fast-medium pace bowler ◯ Medium pace bowler
Do you know your bowling speed?	◯ Yes ◯ No
At what speed to you usually bowl? (km/hr)	__________________________________
Are you a right or left handed bowler?	◯ Right ◯ Left
What is your bowling position?	◯ Opening bowler ◯ First change ◯ Second change ◯ Third change ◯ Other
Please specify	__________________________________
What is your preferred fielding position?	◯ Inner circle ◯ Outer circle
What is your bowling action type?	◯ Front-on ◯ Side-on ◯ Mixed ◯ Other
Please specify the bowling action you bowl with.	__________________________________
For how long have you been a pace bowler? (years)	__________________________________

Preseason conditioning

Did you partake in any pe-seaon cricket and non-cricket-related activities or training?	◯ Yes ◯ No
Which activities did you partake in?	☐ Bowling ☐ Batting ☐ Fielding ☐ Upper body strength training ☐ Lower body strength training ☐ Cardio-vascular exercise ☐ Other

Please specify which other activity(ies) you took part in.	__________________________________

Injury information

Are you currently suffering from an injury?	◯ Yes ◯ No (Injury definition: any neuromusculoskeletal condition which affects your ability to perform during a match or training; this includes any chronic condition which you started the season with, or developed during the season.)
In which body region did the injury occur?	__________________________________
Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the initial injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether this injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other

You chose "other" - please specify	__________________________
Please briefly state how the injury occurred	________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No
Apart from your current injury, have you sustained any other previous injuries since you started playing cricket?	◯ Yes ◯ No
In which body region(s) was/were the injury(ies)?	☐ Head or face ☐ Neck ☐ Shoulder ☐ Elbow ☐ Wrist or hand ☐ Sternum/ribs/upper back ☐ Low back ☐ Hip/groin/buttock ☐ Knee ☐ Shin ☐ Foot/ankle ☐ Other

Head or face injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Neck injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	____
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Shoulder injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Elbow injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.

____

Were you unable to train for a certain period of time due to the injury?
- ◯ Yes
- ◯ No

How long were you unable to train for?
- ◯ < 1 week
- ◯ 1-3 weeks
- ◯ 4-8 weeks
- ◯ 9-12 weeks
- ◯ 3-6 months
- ◯ > 6months

Were you unable to play in matches due to the injury?
- ◯ Yes
- ◯ No

How many matches were you unable to participate in as a result of the injury?
- ◯ 1 match
- ◯ 2-4 matches
- ◯ 5-6 matches
- ◯ 7-8 matches
- ◯ > 8 matches

During which part of the season did the injury(ies) occur?
- ◯ Pre-season
- ◯ First two months
- ◯ Middle four months
- ◯ Last two months
- ◯ After the season

Which year did the injury take place?
- ◯ 2016
- ◯ 2015
- ◯ 2014
- ◯ 2013
- ◯ 2012
- ◯ before 2012

How did you manage this injury?
- ◯ Surgery
- ◯ Medication
- ◯ Physiotherapy
- ◯ Strapping
- ◯ Wore a brace
- ◯ Alternative medicine (chiro, reflexologist, etc)
- ◯ Rest
- ◯ No treatment
- ◯ Other

Wrist or hand injury

On which side did you sustain your injury?
- ◯ Left
- ◯ Right
- ◯ Center

How did the injury occur?
- ◯ Contact
- ◯ Non-contact

(A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Sternum/ribs/upper back injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Low back injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Hip/groin/buttock injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Knee injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Shin injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Foot/ankle injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)

Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Other injury

On which side did you sustain your injury?	◯ Left ◯ Right ◯ Center
Please state the body area which sustained the injury	__________________________________

How did the injury occur?	◯ Contact ◯ Non-contact (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Please describe briefly how the injury occurred.	__________________________________
Were you unable to train for a certain period of time due to the injury?	◯ Yes ◯ No
How long were you unable to train for?	◯ < 1 week ◯ 1-3 weeks ◯ 4-8 weeks ◯ 9-12 weeks ◯ 3-6 months ◯ > 6months
Were you unable to play in matches due to the injury?	◯ Yes ◯ No
How many matches were you unable to participate in as a result of the injury?	◯ 1 match ◯ 2-4 matches ◯ 5-6 matches ◯ 7-8 matches ◯ > 8 matches
During which part of the season did the injury(ies) occur?	◯ Pre-season ◯ First two months ◯ Middle four months ◯ Last two months ◯ After the season
Which year did the injury take place?	◯ 2016 ◯ 2015 ◯ 2014 ◯ 2013 ◯ 2012 ◯ before 2012
How did you manage this injury?	◯ Surgery ◯ Medication ◯ Physiotherapy ◯ Strapping ◯ Wore a brace ◯ Alternative medicine (chiro, reflexologist, etc) ◯ Rest ◯ No treatment ◯ Other

Injury Surveillance Questionnaire

Please complete the survey below.

Thank you!

Injury information

Have you suffered from an injury in the last month? (if you can't clearly remember whether you reported an injury yet or not, just report it anyway)	◯ Yes ◯ No (Injury definition: any neuromusculoskeletal condition which affects your ability to perform during a match or training; this includes any chronic condition which you started the season with, or developed during the season.)

If you have not sustained an injury this month then no further information is needed.

In your opinion, has a change in your bowling/training workload/intensity played a role in the development of your injury/pain?	◯ Yes, an increased workload/intensity ◯ Yes, a decreased workload/intensity ◯ No
Please tick the areas injured in the last month.	☐ Head or face ☐ Neck ☐ Shoulder ☐ Upper arm ☐ Elbow ☐ Forearm ☐ Wrist ☐ Hand/finger ☐ Chest injury ☐ Trunk and abdominal ☐ Thoracic spine ☐ low back ☐ Pelvis/buttocks (excluding groin) ☐ Hip and groin ☐ Thigh (hamstring) ☐ Thigh (quadriceps) ☐ Knee ☐ Lower leg ☐ Ankle ☐ Foot ☐ Injury site unspecific or crossing anatomical boundaries ☐ Others, please specify

Please indicate what the nature of the injuries you sustained

	Joint Sprain	Joint dislocation	Muscle injury	Fracture	Nerve injury	Cut or graze	Organ injury	Other
Head or face injury	○	○	○	○	○	○	○	○
Neck injury	○	○	○	○	○	○	○	○
Shoulder injury	○	○	○	○	○	○	○	○
Upper arm injury	○	○	○	○	○	○	○	○
Elbow injury	○	○	○	○	○	○	○	○
Forearm injury	○	○	○	○	○	○	○	○
Wrist injury	○	○	○	○	○	○	○	○
Hand/finger injury	○	○	○	○	○	○	○	○
Chest injury	○	○	○	○	○	○	○	○
Trunk injury	○	○	○	○	○	○	○	○
Abdominal injury	○	○	○	○	○	○	○	○
Thoracic spine injury	○	○	○	○	○	○	○	○
Low back injury	○	○	○	○	○	○	○	○
Pelvis/buttock (excl groin) injury	○	○	○	○	○	○	○	○
Hip/groin injury	○	○	○	○	○	○	○	○
Hamstring injury	○	○	○	○	○	○	○	○
Quadriceps injury	○	○	○	○	○	○	○	○
Knee injury	○	○	○	○	○	○	○	○
Lower leg injury	○	○	○	○	○	○	○	○
Ankle injury	○	○	○	○	○	○	○	○
Foot injury	○	○	○	○	○	○	○	○
Injury site unspecific or crossing anatomical boundaries	○	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○	○

You chose "injury site unspecific or crossing anatomical boundaries", please specify __________________________________

You chose "other" injury, please specify __________________________________

You chose "other" as the nature of your head or face injury, please specify __________________________________

You chose "other" in describing the nature of your neck injury, please specify __________________________________

You chose "other" in describing the nature of your shoulder injury, please specify __________________________________

You chose "other" in describing the nature of your upper arm injury, please specify __________________________________

You chose "other" in describing the nature of your elbow injury, please specify __________________________________

You chose "other" in describing the nature of your forearm injury, please specify	______________________
You chose "other" in describing the nature of your wrist injury, please specify	______________________
You chose "other" in describing the nature of your hand injury, please specify	______________________
You chose "other" in describing the nature of your chest injury, please specify	______________________
You chose "other" in describing the nature of your trunk injury, please specify	______________________
You chose "other" in describing the nature of your abdominal injury, please specify	______________________
You chose "other" in describing the nature of your thoracic injury, please specify	______________________
You chose "other" in describing the nature of your low back injury, please specify	______________________
You chose "other" in describing the nature of your pelvis/buttock (excl groin) injury, please specify	______________________
You chose "other" in describing the nature of your hip/groin injury, please specify	______________________
You chose "other" in describing the nature of your hamstring injury, please specify	______________________
You chose "other" in describing the nature of your quadriceps injury, please specify	______________________
You chose "other" in describing the nature of your knee injury, please specify	______________________
You chose "other" in describing the nature of your lower leg injury, please specify	______________________
You chose "other" in describing the nature of your ankle injury, please specify	______________________
You chose "other" in describing the nature of your foot injury, please specify	______________________
You chose "other" in describing the nature of your injury which is unspecific or crossing anatomical boundaries, please specify	______________________
You chose "other" in describing the nature of your other injury, please specify	______________________

Please answer the following relating to your head or face injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the initial injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________
Approximate duration of symptoms (weeks)	__________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________
Please briefly state how the injury occurred	________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your neck injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the initial injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________________
Please briefly state how the injury occurred	_____________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your shoulder injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the initial injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________
Approximate duration of symptoms (weeks)	__________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________
Please briefly state how the injury occurred	________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your upper arm injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your elbow injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________
Approximate duration of symptoms (weeks)	__________________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your forearm injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade). A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered.)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your wrist injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________
Please briefly state how the injury occurred	____________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your hand_finger injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your chest injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________
Approximate duration of symptoms (weeks)	__________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________
Please briefly state how the injury occurred	________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your trunk injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________
Please briefly state how the injury occurred	____________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your abdominal injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________
Approximate duration of symptoms (weeks)	__________________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your thoracic injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your low back injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your pelvis_buttock injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________
Approximate duration of symptoms (weeks)	__________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your hip_groin injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your hamstring injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________
Please briefly state how the injury occurred	____________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your quadriceps injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your knee injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	________________________________
Approximate duration of symptoms (weeks)	________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your lower leg injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________
Approximate duration of symptoms (weeks)	______________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________
Please briefly state how the injury occurred	____________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your ankle injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	____________________
Approximate duration of symptoms (weeks)	____________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your foot injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014

Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your injury which is unspecific or crossing anatomical boundaries

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	______________________________
Approximate duration of symptoms (weeks)	______________________________
Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	______________________________
Please briefly state how the injury occurred	______________________________________
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other

During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

Please answer the following relating to your other injury

Select the side of the body where the injury occurred	◯ Left ◯ Right ◯ Both sides
Have you previously suffered the same injury? Or is this a chronic injury?	◯ Yes, recurrent ◯ No, no first time ◯ Chronic (A recurrent injury is one to the same side and body part and of the same injury type as an injury that previously qualified as a significant injury earlier in the same season, but which had recovered. An injury is considered recovered once a player has returned to full (unrestricted) participation in at least one match (of any type or grade).)
Please indicate the season in which the injury occurred	☐ 2016 off season ☐ 2015/2016 season ☐ 2015 off season ☐ 2014-2015 ☐ Prior to 2014
Would you describe this injury as a contact injury or as a non-contact injury?	◯ Contact injury ◯ Non-contact injury (A contact injury is when you get injured when colliding with the ground, a ball or another player)
Would you describe this/the initial injury as acute or as gradual onset?	◯ Acute ◯ Gradual onset
Date of injury	__________________________________
Approximate duration of symptoms (weeks)	__________________________________

Please select whether the initial injury occurred during a training session or match	◯ Practice ◯ Match ◯ Other
You chose "other" - please specify	__________________________________
Please briefly state how the injury occurred	____
During which activity did the injury occur?	◯ Bowling ◯ Batting ◯ Fielding ◯ Other
During which match environment did the injury occur?	◯ T20 ◯ 60 Over ◯ 50 Over ◯ 45 Over ◯ Other
Did this injury 1) prevented the player from being fully available for selection for a match or 2) during a match, caused the player to be unable to bat, bowl or keep wicket when required by either the rules or the team's captain?	◯ Yes ◯ No
Was surgery required for this injury?	◯ Yes ◯ No

APPENDIX C: DECLARATION DOCUMENTS, PLAGIARISM AND ETHICS CERTIFICATES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Mr M Dawood
School of Therapeutic Sciences
Department of Physiotherapy
Medical School
University

E-mail: Mdawoodphysio@gmail.com

CC: Supervisor: Professor B Olivier <Benita.Olivier@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 18/08/2018

REF: *R14/49*

PROTOCOL NO: **M180410** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *Shoulder pain in South African premier league fast bowlers: prevalence, incidence, predictive factors and prevention*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Muhammad Dawood(Student number: 2005924) am a student registered for the degree of PHD (philosophy: Physiotherapy) in the academic year 2018.

I hereby declare the following:

I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong. I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise. I have followed the required conventions in referencing the thoughts and ideas of others. I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing. I have attached in this Appendix a report from "Turnitin" indicating that there is only 16% of similarity in my document. The similarity meter is green.

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APPENDIX D: PARTICIPANT INFORMATION SHEETS

STUDY INFORMATION DOCUMENT 1

Study title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

Dear Cricketer,

My name is Muhammad Dawood, a WITS PHD student, this information leaflet is to help you to decide if you would like to participate.

Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved. Fast bowlers like yourself vigorously perform a large quantity of overhead activities per week and this has shown to predispose shoulder injuries and pain.

You are invited to take part in a research study. The aim of my study is to determine which factors could contribute to shoulder pain in bowlers and attempt to prevent shoulder injuries and pain by modifying these factors by doing so we wish to learn more about cause of shoulder pain in Premier League fast bowlers. Some problems could be serious and if identified early could save you from having problems later on as well as possibly increase the performance and the pace at which you bowl.

This study involves answering some questions with regard to your injury/pain. We would like you to complete a questionnaire. This may take about five minutes to ten (10) minutes depending on your medical history. This will be done at the session where your consent is given. The questionnaire will be kept in a safe place to ensure confidentiality. Please do not enter your name on the questionnaire only your email address. This will ensure confidentiality. I will be available to help you with the questionnaire. Weight and height, measurements will also be done. We will then perform a few shoulder movements and strength tests. This will require you to remove your shirt. After these tests you will be explained that you will have to fill out a questionnaire weekly, this questionnaire will be online and take approximately five minutes to ten minutes of your time.

Risks of being involved in the study:
The one possible risk involved is muscle and joint stiffness from the shoulder testing although this is highly unlikely. In the event that discomfort and/or stiffness is resulting from the testing procedure you will be managed by myself for this said stiffness and/or discomfort.

Benefits of being in the study:

Many of these tests are done routinely on patients. It will enable us to treat you if you should have problems. We will be able to determine your risk of injury and help you prevent it. Muscle strength and performance are likely to increase as well. It is important to note that the benefits of the study may not be immediate.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the Participant is otherwise entitled. There is no requirement to provide a reason for withdrawing and any data collected on such a person will in default be destroyed, unless the Participant specifically consents to its retention.

Confidentiality: Personal information will be treated in the strictest confidence and will only be available to the Principal Investigator (PI) and his/her Supervisor, in the case wherein the PI is a postgraduate student. The only exceptions - and all of them are rare - would normally be:
personal information may be disclosed if required by law

the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit

the South African Health Products Regulatory Authority (SAHPRA), which is the successor body to the South African Medicines Control Council (SAMCC), might conceivably require access to personal data, if conducting an investigation into a drug trial

If results are published, this may, exceptionally, lead to cohort, or more rarely, individual identification. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

All records obtained whilst in this study will be regarded as confidential. Results will be published or presented in such a fashion that patients remain unidentifiable.

Contact details of researcher/s: Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com,

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.olivier@wits.ac.za
.

Outputs
The results of this study as well as the consequential developed exercise programme for shoulder pain and shoulder pain prevention will be shared with the premier league cricket clubs as well as the Northerns Cricket Union and Cricket South Africa.

Contact details of HREC administrator and chair – for reporting of complaints / problems. The following text is recommended:

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this

Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.
If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Date: June 2018

STUDY INFORMATION DOCUMENT 2

Study title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

Dear Cricketer,

My name is Muhammad Dawood, a WITS PHD student, this information leaflet is to help you to decide if you would like to participate.

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You are invited to take part in a research study. The aim of my study is to develop a programme that will address the biomechanical factors associated with shoulder pain in cricketers.

This study involves answering some questions with regard to your injury/pain. We would like you to complete a questionnaire. This may take about five minutes to ten (10) minutes depending on your medical history. This will be done at the session where your consent is given. The questionnaire will be kept in a safe place to ensure confidentiality. Please do not enter your name on the questionnaire only your email address. This will ensure confidentiality.. Weight and height, measurements will also be done. We will then perform a few shoulder movements and strength tests. This will require you to remove your shirt. After these tests you will be explained that you will have to perform a weekly exercise programme for six weeks. At the end of the six weeks the tests done at the beginning of the study will be done again.

Risks of being involved in the study:
The one possible risk involved is muscle and joint stiffness from the shoulder testing although this is highly unlikely. In the event that discomfort and/or stiffness is resulting from the testing procedure you will be managed by myself for this said stiffness and/or discomfort.

Benefits of being in the study:

Many of these tests are done routinely on patients. It will enable us to treat you if you should have problems. We will be able to determine your risk of injury and help you prevent it. Muscle strength and performance are likely to increase as well. It is important to note that the benefits of the study may not be immediate.

<u>Participation is voluntary</u>, refusal to participate will involve no penalty or loss of benefits to which the Participant is otherwise entitled. There is no requirement to provide a reason for withdrawing and any data collected on such a person will in default be destroyed, unless the Participant specifically consents to its retention.

Confidentiality: Personal information will be treated in the strictest confidence and will only be available to the Principal Investigator (PI) and his/her Supervisor, in the case wherein the PI is a postgraduate student. The only exceptions - and all of them are rare - would normally be:
1: personal information may be disclosed if required by law.
2: The Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit
3:The South African Health Products Regulatory Authority (SAHPRA), which is the successor body to the South African Medicines Control Council (SAMCC), might conceivably require access to personal data, if conducting an investigation into a drug trial

If results are published, this may, exceptionally, lead to cohort, or more rarely, individual identification. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

All records obtained whilst in this study will be regarded as confidential. Results will be published or presented in such a fashion that patients remain unidentifiable.

Contact details of researcher/s: Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com,

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.olivier@wits.ac.za
.

Outputs
The results of this study as well as the consequential developed exercise programme for shoulder pain and shoulder pain prevention will be shared with the premier league cricket clubs as well as the Northerns Cricket Union and Cricket South Africa.

Contact details of HREC administrator and chair – for reporting of complaints / problems. The following text is recommended:

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (“Committee”). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Date: June 2018

Delphi Study Round One (reworked round 1)

Dear Expert Physiotherapist,

As per our telephonic communication. The round one of the Delphi had a very wide array of responses making a validation process impossible. The aim of the Delphi in this instance is to develop an exercise programme which needs no equipment to address a few biomechanical impairments found to be associated with shoulder pain in overhead athletes (specifically fast bowlers).

Basically all you have to do is note the impairment and decide if the exercise is suitable or not. In the event that you deep the exercise not suitable please provide an alternative. Responses will be greatly appreciated in 4 working days' time.

Please fill out the tables below. Each table will be related to an exercise aimed at addressing a biomechanical impairment found to be associated with shoulder pain in overhead athletes.

Your correspondence is greatly appreciated. We appreciate your understanding regarding the redevelopment of the phase 1 of the Delphi. Your contribution to this study is invaluable.

Please note: This exercise programme will not be treating shoulder pain, it is merely meant to decrease the incidence of the biomechanical factors found to correlate with shoulder pain in the first phase of this study. Also each cricketer will perform the usual warm up he is accustomed to on match days prior to the commencement of the programme.

Thanking you in advance,

Muhammad Dawood (PhD student, Physiotherapist, Lecturer)
0721182565

Expert Name: **Expert Electronic Signature:**

Delphi Round one.

Table: 1: Impairment this exercise is addressing: Poor endurance of the shoulder mobilisers and dynamic stabiliser muscles.

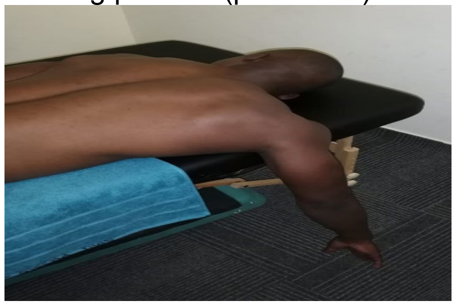
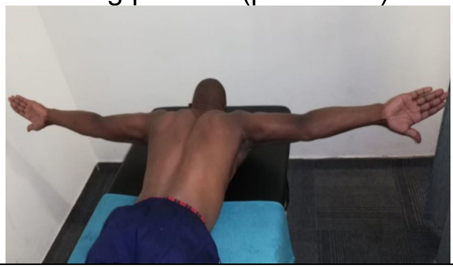
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Scapula retraction exercise (superman T): While lying on a table on your stomach, let the involved arm hang off the side of the table. Turn your hand so your thumb points up. Keeping your elbow straight and your thumb turned up, raise the involved arm up at the side to shoulder height. Squeeze or pinch the shoulder blade as you lift the arm.	2 sets of 15 reps once a day. Starting position (position A):  Finishing position (position B): 	**/10**		

Table: 2: Impairment this exercise is aimed at addressing: Scapula dyskinesia accompanied by poor dynamic stability of the scapula

Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Scapula wall slide: Stand facing a wall, with your feet 1-2 feet from wall. Bend both elbows 90 degrees and raise arms up to shoulder height. With arms slightly wider apart than shoulder width, slowly lean into wall while sliding forearms up wall. Slowly slide arms down wall and return to starting position.	2 sets of 15 reps once a day. Starting position (position A):  Finishing position (position B): 	**/10**		

Table: 3: Impairment this exercise is aimed at addressing: Poor lower fibres of trapezius activation and endurance of the surrounding shoulder muscles in the prone Y position.

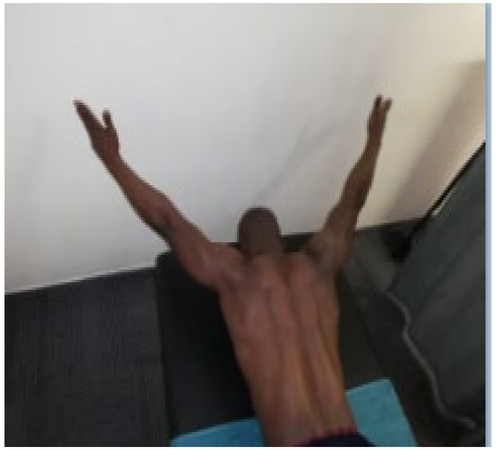
Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Superman exercise (superman Y): While lying on a table on your stomach, let the involved arm hang off the side of the table. Keeping your elbow straight, raise the involved arm up at a 45° angle (as if you were flying through the air like Superman). Squeeze or pinch shoulder blade as you lift the arm.	2 sets of 15 reps once a day. 	**/10**		

Table: 4: Impairment this exercise is aimed at addressing: Poor eccentric strength of the rotator cuff and scapula dyskinesia

Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Eccentric rotator cuff: Sit with your right arm in position A. Gently pull your right arm from position A to position B (using your left arm) whilst controlling the movement for a count of four seconds.	2 sets of 15 reps once a day. Starting position (position A):  Finishing position (position B):	**/10**		

Table: 5: Impairment this exercise is aimed at addressing: Poor positioning (protraction) of the scapula resulting in scapula dyskinesia.

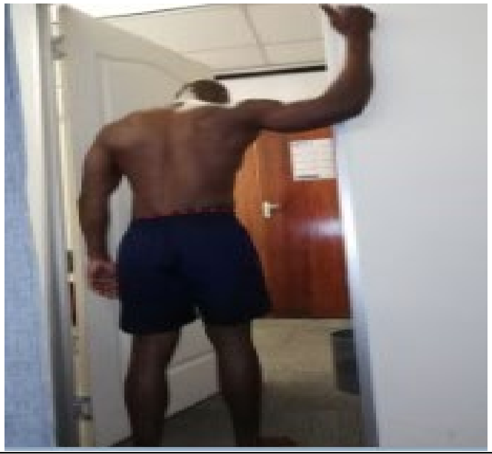
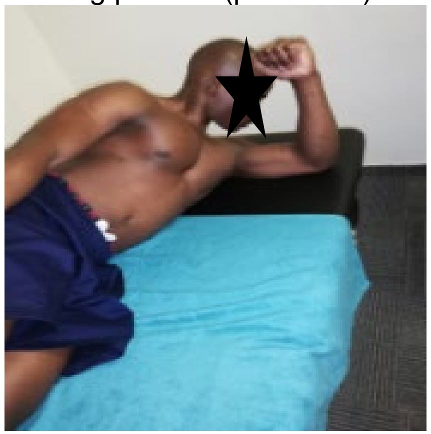
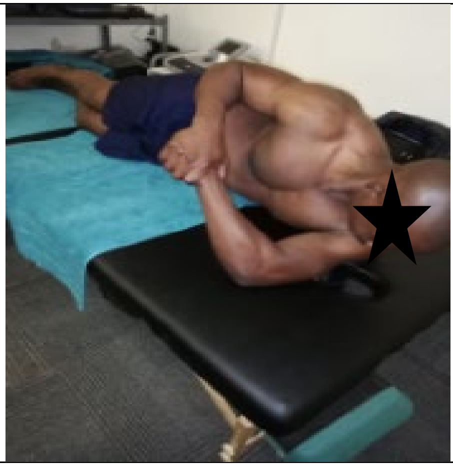
Exercise	Dosage and Illustration	Importance Rating	Include/ Exclude	Suggested exercise (if the expert excludes the exercise in column 1)
Pec Minor Stretch (unilateral corner Stretch): Stand at a doorway and place forearm of involved arm against door frame. Your arm should be out to the side with elbow bent 90 degrees. Keep your back straight and step forward with one leg until a gentle stretch is felt across chest and front of shoulder.	Hold the position for 30 seconds once a day. 	**/10**		

Table: 6: Impairment this exercise is aimed at addressing: decreased internal rotation and a stiff posterior capsule.

Exercise	**Dosage and Illustration**	**Importance Rating**	**Include/ Exclude**	**Suggested exercise (if the expert excludes the exercise in column 1)**
Sleeper stretch: While lying on involved side on a flat surface, extend involved arm out to the side in front of you. Bend the involved elbow 90 degrees, so that your hand is up in the air. Turn your hand so your forearm is facing down. Using the uninvolved hand, push down on the wrist of the involved arm until a gentle stretch is felt in the shoulder.	Hold the position for 30 seconds once a day. Starting position (position A):  Finishing position (position B):	**/10**		

WITS UNIVERSITY

STUDY 3: PARTICIPANT INFORMATION DOCUMENT

Study title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

Dear Cricketer,

My name is Muhammad Dawood, a WITS PHD student. I am required to complete a research project for my degree. I have chosen the study topic listed above and for this purpose I need to recruit a number of volunteer fast bowlers. This information leaflet is to help you to decide if you would be willing to participate in my study.

I am visiting your premier league cricket clubs in the Pretoria area to explain my study, answer questions and ask for volunteers.

To help you decide whether to take part in this study, you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask me. You should not agree to take part unless you are completely happy about all the procedures involved. Cricketers like yourself vigorously perform a large quantity of overhead activities per week and this has been shown to predispose these cricketers to shoulder injuries and pain.

The aim of my study's phase 1 and 2 was to determine which factors could contribute to shoulder pain in bowlers and attempt to prevent future shoulder injuries and pain by designing a specific shoulder targeted exercise programme. We particularly wish to learn more about cause of shoulder pain in Premier League cricketers. Some problems could be serious and if identified early could save you from having problems later on, as well as possibly increase your performance and the pace at which you bowl and throw.

This study starts by asking you to answer some questions with regard to your injury/pain history. Even though your email address and name will be entered into the programme, it will remain in the programme confidentially and will not be accessed so you will remain anonymous. I will be available at all times (contact details below) to help you with the questionnaire, if necessary. I will ask willing participants to allow me to take weight and height measurements. We will then perform a few shoulder movements and strength tests. This will require you to remove your shirt.

After these tests, the final stage of my study will be to request that you perform 6 exercises three times per week on alternating days for 6 weeks. You will also be needed to log your exercises in a booklet which is provided.

Risks of being involved in the study:
The one possible risk involved is muscle and joint stiffness from the shoulder testing and exercise although this is highly unlikely. In the event that discomfort and/or stiffness is resulting from the testing procedure, you will be managed by myself for this said stiffness and/or discomfort.

Benefits of being in the study:
Many of these tests and exercises are done routinely on patients. It will enable us to treat you if you should have problems. We will be able to determine your risk of injury and help you prevent it. Muscle strength and performance are likely to increase as well. It is important to note that the benefits of the study may not be immediate. There is neither payment nor cost associated with being involved in this study.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. There is no requirement to provide a reason for subsequently withdrawing and any data collected on you will in default be destroyed, unless you specifically consent to its retention.

Confidentiality: Personal information will be treated in the strictest confidence and will only be available to me, the Principal Investigator (PI) and my Supervisor. The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law
2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit
3. the South African Health Products Regulatory Authority (SAHPRA), which is the successor body to the South African Medicines Control Council (SAMCC), might conceivably require access to personal data, if conducting an investigation into a drug trial

If results are published, this may, exceptionally, lead to cohort, or more rarely, individual identification. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

Contact details of researcher: Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.Olivier@wits.ac.za

Outputs

The results of this study as well as the consequential developed exercise programme for shoulder pain and shoulder pain prevention will be shared with the Premier League cricket clubs, as well as the Northerns Cricket Union and Cricket South Africa.

Ethical Clearance

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

APPENDIX E: INFORMED CONSENT FORMS

STUDY ONE: INFORMED CONSENT FORM

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET

Project Title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
I was given time to read it, or had it read to me, in the language I best understand;
I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
I believe I fully understand why the study is being conducted and what the intended outcomes will be;
I understand that there may be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com,

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.olivier@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: ______________________________
Date: ______________________________
Place: ______________________________
Signature or mark ______________________________

Witnessed by:

Name of Witness: ______________________________
Signature: ______________________________
Date: ______________________________

STUDY TWO: INFORMED CONSENT FORM

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET (Delphi)

Project Title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there may be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com,

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.olivier@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: ______________________________
Date: ______________________________
Place: ______________________________
Signature or mark ______________________________

STUDY THREE: INFORMED CONSENT FORM

STUDY 3: PARTICIPANT CONSENT SHEET

Project Title: Shoulder pain in South African Premier League fast bowlers: Incidence, risk factors and prevention.

8. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
9. I was given time to read it, or had it read to me, in the language I best understand;
10. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
11. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
12. I understand that there may be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
13. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
14. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Muhammad Dawood, Principal Investigator, telephone no. +27 72 1182 565, or by e-mail at Mdawoodphysio@gmail.com,

Professor Benita Olivier, Supervisor, on telephone no. +27 11 717 2014, or by e-mail at Benita.olivier@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: ________________________________
Date: ________________________________
Place: ________________________________
Signature or mark ________________________________

Witnessed by:

Name of Witness: ________________________________
Signature: ________________________________
Date: ________________________________

APPENDIX F – DATA COLLECTION SHEETS

Date: 2020:

Cricketer Name: Hand dominance:

Club and team:

Email: Cell Phone Number:

Previous Shoulder injury and/or pain:

Details:

Weight(kg): Height(m):

Any current injuries/surgeries/disease (applicable to the shoulder): Include/Exclude:

Comments on the exercise programme (applicable to study 3 only):

Pain with any exercise (applicable to study 3 only):

General feedback (applicable to study 3 only):

Test	**Details:**			**Interpretation:**
Visual anologue scale (VAS) if present	Score:______0/10			
SDT (Dynamic scapula dyskinesis test weighted – 3kg)	Weighted Flexion:	Weighted Abduction:		Normal Subtle Abnormal (Circle one)
SDT (Dynamic scapula dyskinesis test no weight)	Flexion:	Abduction:		Normal Subtle Abnormal (Circle one)
The closed kinetic upper extremity stability test.(CKUES)	Number of touches:	Normalized score:	Power:	
Fatigue testing by means of the Borg scale.	Scaption: ___Reps	Prone Y:___Reps		

Isometric strength testing (IST) **3 measurements and an average noted (record all three)**	**Muscles:**	**Dynamometer reading (Left)**	**Dynamometer reading (right)**
	Rotator cuff (Lying supine external rotation)	Reading 1: Reading 2: Reading 3: Average:	Reading 1: Reading 2: Reading 3: Average:
	Subscapularis (lying supine medial rotation)	Reading 1: Reading 2: Reading 3: Average:	Reading 1: Reading 2: Reading 3: Average:

	Deltoid (Seated in 90 degrees of abduction)		Reading 1: Reading 2: Reading 3: Average:	Reading 1: Reading 2: Reading 3: Average:
	Rhomboids (Prone thumbs down scapula retraction)		Reading 1: Reading 2: Reading 3: Average:	Reading 1: Reading 2: Reading 3: Average:
	Serratus Anterior (supine and serratus push up scapula protraction)		Reading 1: Reading 2: Reading 3: Average:	Reading 1: Reading 2: Reading 3: Average:
Glenohumeral internal rotation (IR) and external rotation (ER) test (GHIRERT) in side lying Dominant =	Passive External rotation ROM:________ Active external rotation ROM: ____________ **Dominant Side**	Passive internal rotation ROM: ______ Active internal rotation ROM : __________________ **Dominant Side**	Total arc of ROM Active: ______________________ Total arc of ROM Passive: ______________________ **Dominant Side**	
Glenohumeral internal rotation (IR) and external rotation (ER) test (GHIRERT) in side lying Non-Dominant =	Passive External rotation ROM:________ Active external rotation ROM: ____________	Passive internal rotation ROM: ______ Active internal rotation ROM: __________________	Total arc of ROM Active: ______________________ Total arc of ROM Passive: ______________________	

APPENDIX G –

THE FINAL EVIDENCE BASED BIOMECHANICAL SHOULDER IMPAIRMENT EXERCISE PROGRAMME AND LOG BOOK

6 Week Shoulder Exercise programme

Dear Premier League Cricketer,

Thank you for your participation in my study. Your input and participation is greatly appreciated.

Below is your custom exercise programme of which the importance is explained to you in the previous documents that you have signed. The programme below has to be performed three times per week on a Monday, Wednesday and Friday preferably at a constant time of the day. These are the steps to follow:

Important note: please follow the order of the steps and exercises given.

Step 1: Warm-up, this should be your normal warm up programme that you would use before a training session or a match, this should be consistent on each day that your programme is done.

Step 2: Perform the exercise programme in the order illustrated and described below. This needs to be performed at around about the same time each Monday, Wednesday and Friday. NB, please follow the order of the steps and exercises given.

Step 3: Log your progress and comments in the logbook provided in the columns below (next to each exercise). A simple tick in the box provided (below each day listed) to indicate that the exercise is done is good enough. If there are any comments they can be logged in the comment section below.

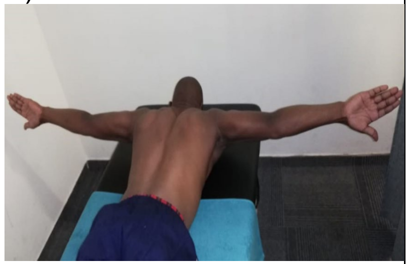
Please feel free to contact me regarding any concerns or queries:

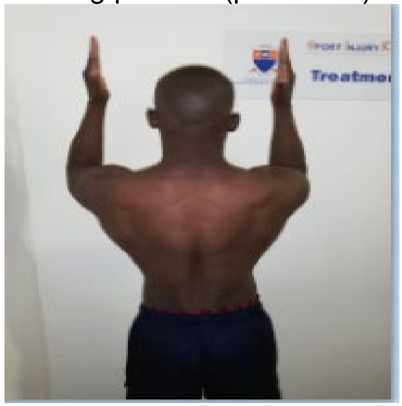
Muhammad Dawood (Primary researcher)

0721182565

Mdawoodphysio@gmail.com

Cricketer Full Name: ______________________________

Exercise	Dosage and Illustration	Weekday (1-6 weeks):					
Exercise 1: Scapula retraction exercise (superman T): While lying on a table, plinth, bed on your stomach, let your arms hang off the side of the table/bed/plinth. Turn your hand so your thumb points down. Keeping your elbow straight and your thumb turned up, raise the involved arm up at the side to shoulder height. Squeeze or pinch your shoulder blades as you lift the arm. The squeeze should be felt in your upper back next to your shoulder blades.	**2 sets of 15 reps** once a day. If you notice that your form is affected you can pause in between and resume after. Starting position (position A):  Finishing position (position B): 	Monday 1: ☐ Wednesday 1: ☐ Friday 1: ☐	Monday 2: ☐ Wednesday 2: ☐ Friday 2: ☐	Monday 3: ☐ Wednesday 3: ☐ Friday 3: ☐	Monday 4: ☐ Wednesday 4: ☐ Friday 4: ☐	Monday 5: ☐ Wednesday 5: ☐ Friday 5: ☐	Monday 6: ☐ Wednesday 6: ☐ Friday 6: ☐

Exercise 2: Scapula wall slide: Stand facing a wall, with your feet 1-2 feet from wall. Bend both elbows 90 degrees and raise arms up to shoulder height and do not take your arms too far away from the body. **With arms slightly wider apart than** shoulder width, slowly lean into wall while sliding forearms up wall. Slowly slide arms down wall and return to starting position. Tip: make sure the wall surface is smooth and either use a long sleeve top or lubrication on your elbows.	**2 sets of 15 reps** once a day. If you notice that your form is affected you can pause in between reps or sets and resume once the fatigue has subsided. Starting position (position A):  Finishing position (position B): 	Monday 1: Monday 2: Monday 3: Monday 4: Monday 5: Monday 6: Wednesday 1: Wednesday 2: Wednesday 3: Wednesday 4: Wednesday 5: Wednesday 6: Friday 1: Friday 2: Friday 3: Friday 4: Friday 5: Friday 6:

Exercise 3: Superman exercise (superman Y): While lying on a plinth/bed/table on your stomach, let your arms hang off of the plinth/bed/table. Keeping your elbow straight, raise the involved arm up at a 45° angle (as if you were flying through the air like Superman). Pull your shoulder blade downwards as you lift the arm upwards focusing on stabilizing your shoulder blade in order to hold your arms in the position.	**2 sets of 15 reps** once a day. If you notice that your form is affected you can pause in between reps or sets and resume once the fatigue has subsided. 	Monday 1: Monday 2: Monday 3: Monday 4: Monday 5: Monday 6: Wednesday 1: Wednesday 2: Wednesday 3: Wednesday 4: Wednesday 5: Wednesday 6: Friday 1: Friday 2: Friday 3: Friday 4: Friday 5: Friday 6:

Exercise 4: Eccentric rotator cuff: Sit with your right arm in position A. Gently pull your right arm from position A to position B (using your left arm) whilst resisting and controlling the movement for a count of **four seconds**.	**2 sets of 15 reps** once a day. If you notice that your form is affected or you feel discomfort you can pause in between reps or sets and resume once the fatigue has subsided. Starting position (position A):  Finishing position (position B): 	Monday 1: ☐ Monday 2: ☐ Monday 3: ☐ Monday 4: ☐ Monday 5: ☐ Monday 6: ☐ Wednesday 1: ☐ Wednesday 2: ☐ Wednesday 3: ☐ Wednesday 4: ☐ Wednesday 5: ☐ Wednesday 6: ☐ Friday 1: ☐ Friday 2: ☐ Friday 3: ☐ Friday 4: ☐ Friday 5: ☐ Friday 6: ☐

Exercise 5: Sleeper stretch: While lying on involved side on a flat surface, extend involved arm out to the side in front of you. Bend the involved elbow 90 degrees, so that your hand is up in the air. Turn your hand so your forearm is facing down. Using the uninvolved hand, push down on the wrist of the involved arm until a gentle stretch is felt in the shoulder.	Hold the position for **30 seconds** once a day. Starting position (position A):  Finishing position (position B): 	Monday 1: Monday 2: Monday 3: Monday 4: Monday 5: Monday 6: Wednesday 1: Wednesday 2: Wednesday 3: Wednesday 4: Wednesday 5: Wednesday 6: Friday 1: Friday 2: Friday 3: Friday 4: Friday 5: Friday 6:

Exercise 6: Pec Minor Stretch (unilateral corner Stretch): Stand at a doorway and place forearm of involved arm against door frame. Your arm should be out to the side with elbow bent 90 degrees. Keep your back straight and step forward with one leg until a gentle stretch is felt across chest and front of shoulder. NB, gently squeeze the bottom of your shoulder blades down and together whilst you are doing the stretch, you should feel this at the base of your shoulder blades. Please take deep breaths as you hold this stretch for 30 seconds.	Hold the position **for 30 seconds** once a day. 	Monday 1: Wednesday 1: Friday 1:	Monday 2: Wednesday 2: Friday 2:	Monday 3: Wednesday 3: Friday 3:	Monday 4: Wednesday 4: Friday 4:	Monday 5: Wednesday 5: Friday 5:	Monday 6: Wednesday 6: Friday 6:

Comments column: Please fill out at the end of the six weeks

Exercise	Comment/concern	Ease of performing this exercise and the exercise programme throughout the six weeks. Please note any discomfort or difficulty as well as any positives (in terms of mobility, stability, strength and performance) from performing the exercise programme.
Exercise 1: ***Scapula retraction exercise (superman T):***		
Exercise 2: ***Scapula wall slide:***		
Exercise 3: ***Superman exercise (superman Y):***		

<u>Exercise 4:</u> ***Eccentric rotator cuff:***		
<u>Exercise 5:</u> ***Sleeper stretch:***		
<u>Exercise 6:</u> ***Pec Minor Stretch (unilateral corner Stretch):***		