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PHYSIOTHERAPY DEPARTMENT

Development of a shoulder pain prevention programme for wheelchair basketball players in South Africa

RESEARCH REPORT

Student details

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A Research Report submitted to the faculty of health sciences, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy.

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Declaration

I, Tawina Msadala, declare that this research report is my own unaided work. It is being submitted for the Master of Science in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Tawina Msadala

Name of candidate

Signature of candidate

Date: 11/05/2023

Dedication

Dedicated to my mother, Mrs J.D Chikankha. Thank you for your unwavering faith in me.

Acknowledgement

I would like to sincerely thank and appreciate a number of people, without whom this research would not stand a chance.

Dr Siyabonga Kunene, for his guidance and work as my supervisor, his continuous faith in me and for giving me his hand as a crutch. Most of all, his friendship and patience, made this process healthy and memorable.

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My Delphi panel members, for the time and work they put into developing the prevention programme with me. Their dedication and passion were the rock that built this research. Their lessons are too special to forget. The education they provided was beyond anything a classroom could provide.

My family and friends, for their love and support.

I see all of you and I am grateful.

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Abbreviations

ABD	Abduction
ADD	Adduction
ADLS	Activities of daily living
AK	Above knee
BK	Below knee
COG	Centre of gravity
ER	External rotation
FITT	Frequency, intensity, type and time
GHJ	Glenohumeral joint
HBB	Hand Behind the Back
HPCSA	Health Professions Council of South Africa
HREC	Human Research Ethics Committee
IR	Internal rotation
IWBF	International wheelchair basketball federation
JBI	Joanna Briggs Institute
N/A	Not Applicable
PCC	Population Concept Context
PNF	Proprioceptive Neuromuscular Facilitation
PT	Physiotherapist
Reps	Repetitions
ROM	Range of motion
SCI	Spinal Cord Injury
SP	Shoulder pain
SPP-WB	Shoulder pain prevention program in w/c basketball
SPSS	Statistical Package for the Social Sciences
T6	Thoracic 6
WB	Wheelchair basketball
W/C	Wheelchair

Operational definitions

Autonomic dysreflexia: a syndrome of imbalanced sympathetic discharge which may be observed in individuals with SCI typically at or above the T6 level (Dutton, 2019).

Impingement syndrome: A collection of symptoms at the shoulder including pain, diagnosed by special tests including Neer's and Hawkin's Kennedy tests together with other physical symptoms (Watts et al., 2017).

Level T6 of spinal cord injury: thoracic spinal level 6 (Dutton, 2019).

Net torque: sum of all muscle forces around a joint (Van Der Woude et al., 2001).

Para sports: sports played by people with disabilities (http://paralympic.ca/what-parasport).

Pivoting: Turning (Vanlandewijck & Thompson, 2000).

Shoulder Pain: Pain or injury to any structure of the glenohumeral, acromioclavicular, and scapulothoracic joints and their associated structures (Christiana, 2019).

Scapular Dyskinesis: Abnormal positioning of scapular at rest (Aytar et al., 2015).

Sports injury: any athlete experiencing an injury that required medical attention, regardless of the consequences with respect to absence from competition or training (Derman et al., 2018).

V02 max: maximal oxygen uptake (Vanlandewijck & Thompson, 2000).

Abstract

Background

Wheelchair basketball (WB) is plagued with shoulder pain (SP), associated with overuse and muscle imbalances among others, with prevalence rates ranging from 44% to 72% in South Africa. However, its prevention remains uncertain due to the scarcity of research.

Aim

The aim of this study was to map the range of strategies to prevent shoulder injuries and develop an exercise programme suitable for the prevention of SP for WB players in South Africa.

Method

A mixed methods study was conducted beginning with a scoping review followed by a modified Delphi survey. In the review, Scopus, Pubmed, EbscoHost, SportDiscus, Medline complete and CINAHL were searched. Then relevant studies were identified, and an exercise-based injury prevention programme was formulated from the data extracted. Then, in the second part of the study, individual exercises in the programme were rated on a 5-point Likert scale from strongly disagree to strongly agree in three rounds, by an expert panel of four physiotherapists and a sports scientist. The first two rounds were conducted via RedCap and a consensus meeting was conducted via zoom in the third round. Finally, a final shoulder pain prevention programme (SPP) was compiled from the exercises that reached a consensus agreement of ≥80%.

Results

Only five studies were identified from the scoping review. These studies supported strengthening exercises and stretching of the shoulder girdle muscles to prevent shoulder pain in WB and wheelchair sports. One study included a warm-up of active movements of the shoulder. Then, in the Delphi, 39.1% of the exercises reached consensus in the first round, none in the second round and then 75% of modified exercises had 100% agreement in the third round. These exercises formed the final SPP which consisted of muscle endurance, functional and scapular activation exercises in addition to strengthening exercises and stretching.

Conclusion

Few studies have been done on strategies for preventing shoulder pain in WB. A holistic programme incorporating shoulder muscle strength and endurance, scapular stabilisers activation and flexibility exercises may help in preventing shoulder pain among WB players and may inform further experimental research implementing the program.

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Chapter 1 Introduction

1.1 Background

Participation and watching of Paralympic sports has increased over the years, with wheelchair basketball (WB) said to be the most common Paralympic sport (Heyward et al., 2017). In South Africa, the sport is growing as well with a recent increase in its participation. Lepera (2010) suggests that the recent increase in participation in WB in South Africa over the years may be owed to the recent success of local athletes at foreign clubs and increased sponsorship in the sport locally. The Supersport WB series, a televised yearly tournament in which the top six teams in the country participate, is one of the developments that arose with the availability of funds (Lepera, 2010; Mateus & Pillay, 2019).

Essentially, with the increased participation in WB, it is necessary to understand the sport itself. WB has been described as a high intensity sport that involves fast wheelchair propulsion manoeuvres including acceleration, pivoting, quick start and stops for attack and defensive work, and overhead activities including quick passing, shooting and rebounding (Goosey-Tolfrey, Butterworth & Morriss, 2002; Lepera, 2010; De Witte et al., 2017; da Silva et al., 2022).

Historically, WB was established for injured soldiers in 1942 during the second World War (Gómez, 2018). In 1948, the first wheelchair sports competition, the Stoke Mandeville games including WB among other wheelchair sports, was organised by Sir Ludwig and his colleagues. Following that, the International Stoke Mandeville games were established a couple of years later. The Paralympic games were established in 1960 and have since become the main international sporting event for athletes with physical disabilities (Gómez, 2018).

The benefits of participating in sports for people with disabilities are immense. Firstly, sport participation promotes health and physical fitness for people with disabilities much like their able-bodied counterparts or sometimes even more (Burnham et al., 1993; Allender, Cowburn & Foster, 2006; Wilson & Khoo, 2013; Aitchison et al., 2022). For example, WB players, are reported to have a well-developed upper body that is stronger than regular basketball players due to involvement of the upper limbs in daily function as well as sports (Burnham et al., 1993). Physiological adaptations, including increased rate of oxygen consumption (VO_2) and improved extraction of oxygen from blood into cells for use resulting in improved cardiovascular endurance, have been reported for people with spinal cord injuries participating in endurance sports (Vanlandewijck & Thompson, 2011). Brukner & Khan (2017) reported that people with disabilities participating in sports had much less hospital visits than their counterparts that were not physically active. In addition, the psychosocial benefits of participation may be even bigger than the physical benefits. Athletes with disabilities have reported finding a sense of identity, improved social and interpersonal relationships, boosted self-esteem, confidence and sense of accomplishment, feelings of liberty and freedom to be themselves regardless of their disability, and reduction of stress and anxiety, among others (Vanlandewijck & Thompson, 2011; Jefferies, Gallagher & Dunne, 2012; Aitchison et al., 2022).

Conversely, injuries occur in sports including para sports. Generally, athletes with disabilities tend to have a lot of overuse injuries of the upper limb, with shoulder injuries considerably more common than injuries in any other anatomical area (Willick et al., 2013; Derman et al., 2018; Dutton, 2019). Other common upper extremity injuries among athletes with disabilities include nerve entrapment injuries, with carpal tunnel syndrome a regular culprit (Dutton, 2019). Repetitive trauma from repetitive high strain on the shoulder and repetitive wrist flexion and extension respectively, during manual wheelchair propulsion and transfers has been reported to be associated with these types of injuries (Vanlandewijck, Theisen & Daly, 2001; Dutton, 2019). Additionally, athletes with disabilities tend to have reduced bone mass density predisposing them to fractures (Dutton, 2019). Furthermore, unlike able-bodied athletes, athletes with disabilities are at risk of pressure sores from sweating during sports, impaired mobility and sensation, spasticity and incontinence. Athletes with spinal cord injury (SCI) below sixth thoracic vertebrae (T6) are at risk of autonomic dysreflexia (Dutton, 2019).

Similarly, in WB, upper limb injuries are common with the shoulder being the most commonly injured anatomical area. Wheelchair basketball players are involved in overhead activities and continuous use of the upper limbs for manoeuvring the wheelchair when chasing after other athletes and making quick turns and stops. Repetitive overhead activities stress the shoulder joint increasing the chance of developing pain (Lepera, 2010; Yildirim, Comert & Ozengin, 2010; Heyward et al., 2017; Mateus & Pillay, 2019). In addition to this, repetitive overhead positioning is also said to likely lead to subacromial impingement (Yildirim, Comert & Ozengin, 2010).

In addition to overhead activities, WB players are in involved in repetitive hand rim propulsion of a wheelchair during training, competition, sports and for some during activities of daily living (ADL's). The repetitive nature of this may cause fatigue to the rotator cuff and some other shoulder muscles. Moreover there are high forces at the shoulder during hand rim propulsion which may expose the shoulder to injury (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001). Poor sitting posture in the wheelchair, with the pelvis tilted posteriorly, increased thoracic kyphosis and head forward associated with trunk control, may also lead to development of shoulder pain (SP) (Mateus & Pillay, 2019).

Several risk factors have been associated with SP with regards to repetitive wheelchair propulsion mechanics and overhead activities among WB players. Among them are reduced internal rotation range of motion, tightness of posterior structures of the shoulder and muscle imbalances (Wilroy & Hibberd, 2018; Christiana, 2019). In her study, Christiana (2019) reported that training of more than or equal to two hours per day was associated with SP.

In terms of management of SP among WB players, not much research has been documented on effective management strategies. However, Christiana (2019) and Lepera (2010) reported that SP among WB players was managed mostly through physiotherapy that involved icing and some forms of exercises. Few were managed medically using pain killers and fewer still had undergone surgeries for rotator cuff tears. A specialised exercise program was found to be effective in reducing pain among people with chronic spinal cord injuries (Nawoczenski et al., 2006).

To understand the extent of an injury problem, incidence rates should be reported. Unfortunately, in the author's knowledge, studies addressing the incidence of SP among WB players are not available. However, the incidence of shoulder injuries at the London and Rio Paralympic games among athletes with disabilities in general was reported to be higher than other anatomical regions, with incidence rates of 10.5 and 1.8 per 1000 athlete days respectively (Willick et al., 2013; Derman et al., 2018).

That being said, multiple cross-sectional studies have been done reporting the prevalence rate of SP among WB players. Varying ranges of prevalence have been reported with ranges starting from 21% to >70% (Heyward et al., 2017). In South Africa similarly, high prevalence rates have been reported (Lepera, 2010; Christiana, 2019; Mateus & Pillay, 2019). In the Supersport WB series, 54% of the athletes had suffered SP since the start of their career and 44% in the year prior to the study (Mateus & Pillay, 2019).

With high prevalence of shoulder injuries, most research has is still focused on epidemiology and not much on injury prevention (Heyward et al., 2017). The few studies that did, have recommended that exercises would be beneficial in the prevention of SP for athletes with disabilities (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). Two studies suggest that a home-based strengthening and stretching program may improve the characteristics that increase the risk of developing SP (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). Heyward & Hibberd (2018) however report no significant changes in muscle strength post-intervention. García-Gómez et al., (2019) suggest that incorporating a SP prevention program into strength and conditioning is necessary for preventing SP. WB players in South Africa have been reported to train for two hours per day and six hours per week on average. This training though seems to be more focused on WB skills and not strength and conditioning (Lepera, 2010; Christiana, 2019). This study therefore aims to develop an exercise programme suitable for the prevention of shoulder pain for WB players in Johannesburg with the focus on inclusion of adequate strength and conditioning as well.

1.2 Problem statement

Shoulder injury is a common problem in wheelchair basketball (Heyward et al., 2017; Mateus & Pillay, 2019). With participation and popularity of the sport increasing, it is necessary to prevent shoulder injuries as they affect participation in sports including WB and negatively impact the quality of life of athletes (Vanlandewijck & Thompson, 2000). Generally, studies focusing on SP in wheelchair sports including WB are scarce (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). Moreover, the strengthening exercises in the developed programs use therabands for strengthening shoulder muscles which may not be adequate to improve strength in WB players who undergo intense strength and conditioning for training (Wilroy & Hibberd, 2018). No study has developed a prevention program incorporating robust strengthening exercises to prevent such common injuries. In South Africa, recent research has focused on the epidemiology of shoulder injuries and identifying the associated risk factors (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). This study therefore aims to outline the range of preventive strategies available and to develop an exercise programme for the prevention of shoulder injuries in WB players in South Africa.

1.3 Aims and objectives

1.3.1 Aim

To map the range of strategies to prevent shoulder injuries and develop an exercise programme for the prevention of shoulder pain among wheelchair basketball players in South Africa through an expert-based consensus.

1.3.2 Objectives

i. To conduct a scoping literature review on current preventive strategies for shoulder pain in overhead sports.

ii. To identify suitable exercises to be included in the shoulder pain prevention programme for wheelchair basketball players.

iii. To obtain experts' consensus on exercises to be included in the shoulder pain prevention programme for wheelchair basketball players.

1.4 Significance

Shoulder pain not only negatively affects performance in WB sport; it also negatively impacts the quality of life for WB players that are wheelchair users because they use their upper limbs for activities of daily living (ADLs) including mobility and transfers. Most studies have focused on the epidemiology of SP as opposed to focusing on prevention. Because WB players in South Africa appear to train more on WB skills and not enough strength and conditioning, there is need for a prevention program that also incorporates this aspect. This study may help coaching teams effectively implement their training strategies with prevention of SP also being focused on. It may also potentially help WB players learn prevention strategies for SP and provide information to learners to explore this topic further by conducting experimental studies to evaluate the effectiveness of the SP prevention programme among WB players.

1.5 Outline of this research report

The outline for the research report is illustrated in figure 1.1 below, from the first chapter; introduction all the way to chapter 6; conclusion and recommendations and references and appendices.

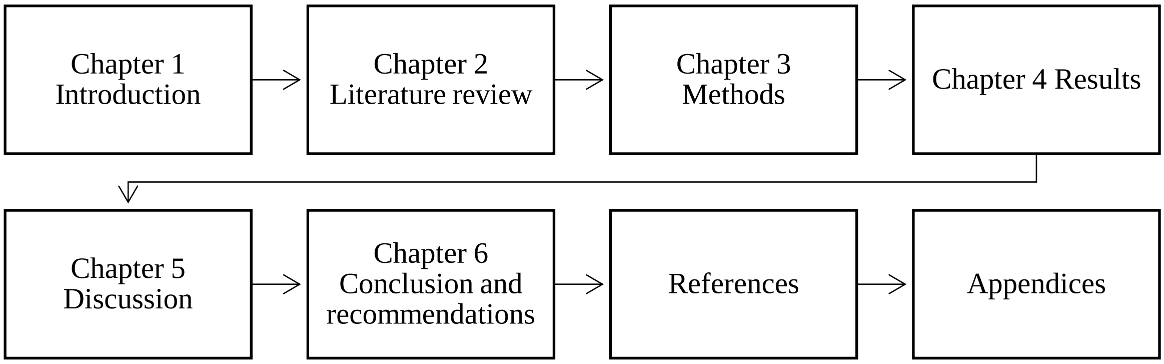

Figure 1.1 Outline of research report

Chapter 2 Literature Review

2.1 Introduction

Shoulder pain (SP) poses a significant challenge among WB players, that the need for its prevention cannot be over emphasised. This review will begin by providing insight into the rules and mechanics of WB to better guide the reader into understanding why SP is so prevalent in the sport. Then, following the systematic approach to injury prevention, as described by van Mechelen, Hlobil & Kemper (1992) further developed by Finch (2006) and Bolling et al (2018), this chapter will establish the extent of the SP problem in WB, the risk factors associated with it and the preventive measures that have been discussed and implemented thus far. Because the focus of this study is prevention of SP in WB, SP in other disability sports will only be mentioned as necessary in this review.

2.2 Search strategy

Pubmed and Ebsco Host (incorporating Medline, SportDiscus and CINAHL) were searched through the University of Witwatersrand library. Keywords used were shoulder pain or injury, wheelchair basketball, injury prevention or injury prevention program, and wheelchair basketball biomechanics. Articles found from references were searched on Googlescholar.

2.3 Wheelchair basketball rules

Wheelchair basketball is a high intensity sport that is played on a hard court and consists of four quarters each lasting ten minutes, with very little breaks in between except half-time, which has a longer break of fifteen minutes. Each side consists of five players playing at any given moment, with a maximum of 14 points per team allowed during any match (IWBF Executive Council, 2021). In this section, the classification of WB is discussed.

2.3.1 Classification of wheelchair basketball players

WB players have a diverse range of disabilities that can be grouped into neurological and musculoskeletal disabilities (Van Der Woude et al., 2001). Neurological disabilities among WB players include spinal cord injury, cerebral palsy, and poliomyelitis among others. The most notable musculoskeletal disability is limb deficiency (Van Der Woude et al., 2001; IWBF, 2021).

Because of the variety of conditions that WB players present with, classification is done to group the players according to their function and overall ability. The classification system ensures that there is a balance in the functional capabilities of the teams and that they out-perform each other based on their skill(s) as opposed to their impairments. It is also done to determine a player's the eligibility to participate in a WB tournament (IWBF Executive Council, 2021).

Generally, players are classified on an 8-point classification system with an interval of 0.5, by classifiers officially trained by the International Federation of Wheelchair Basketball (IWBF). Each class (Figures 2.1 and 2.2) has unique characteristics depending on their trunk, and upper and lower limb function. The method used to classify players is termed the volume of action which is defined as the extent that a player can freely move their trunk and hands in any direction and return back to their original upright position, without holding their wheelchair for support (IWBF, 2021).

So, using the volume of action, class 1.0 and 2.0 players (Figure 2.1 below) require the use of their hands to return to an upright seating position once unbalanced. Yildirim, Comert & Ozengin (2010) grouped these classes together and referred to all players classified below three as low point players. Generally, these players have no active pelvic stability and so require passive stabilisation (IWBF Executive Council, 2021). However, there are some differences in these two groups as well. Class 1.0 players have no active trunk control and movement in rotation and bending forward or sideways (left or right). These players are said to have the least volume of action. Meanwhile, class 2.0 players have partial volume of action in trunk rotation and forward bending. They, however, have no control in bending of their trunk to the left or right and they can hold the ball with both of their arms outstretched (IWBF Executive Council, 2021).

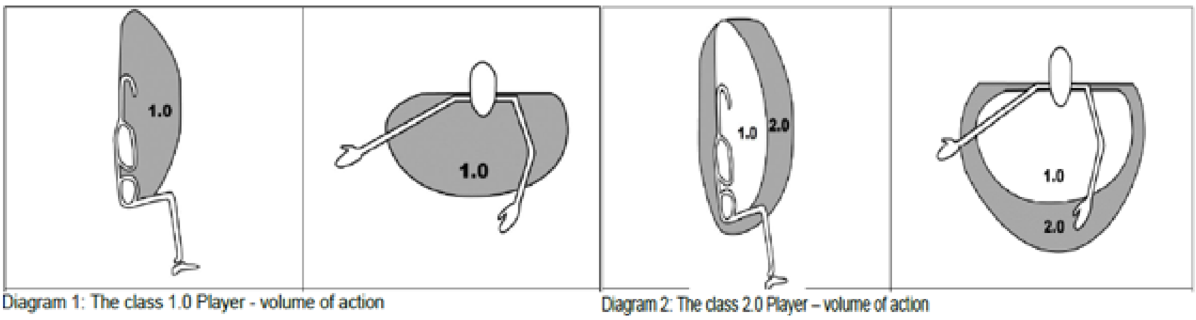

Figure 2.1 Volume of action of classes 1.0 and 2.0 (IWBF, 2021)

In contrast, players classified above 3.0 (figure 2.2) have been termed as high point players (Yildirim, Comert & Ozengin, 2010) and they generally have active pelvic stability (IWBF Executive Council, 2021). Class 3.0 players have complete forward trunk movement and rotation, and can return upright from forward bending without use of their hands. They, however, have no controlled trunk movement when bending sideways and so require use of one hand at least to return to an upright sitting position from a sideways position. While class 4.0 players also have complete trunk movement and control in forward bending and rotation, they differ from class 3.0 in that they have complete trunk movement laterally to one side (left or right). They can hold the ball over their head without loss of stability. Finally, Class 4.5 players have complete trunk movement in all sides in addition to trunk rotation and forward and backward movement. In circumstances where a player does not seem to fit a single category, they are classified using a 0.5 basis, placing them in classes 1.5, 2.5 or 3.5.

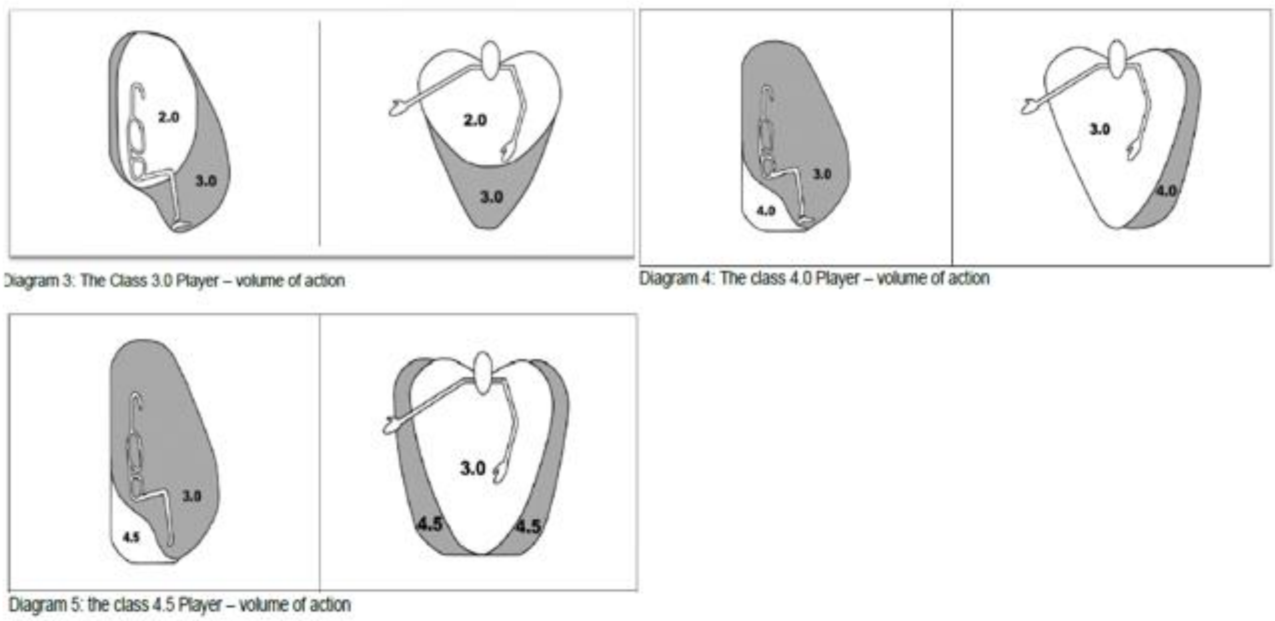

Figure 2.2 Volume of action of WB players ≥ 3.0 (IWBF, 2021)

On the other hand, as opposed to the volume of action, WB players with limb deficiencies are classified based the level of the amputation and whether they are amputated on both left and right sides (Figure 2.3) (IWBF Executive Council, 2021).

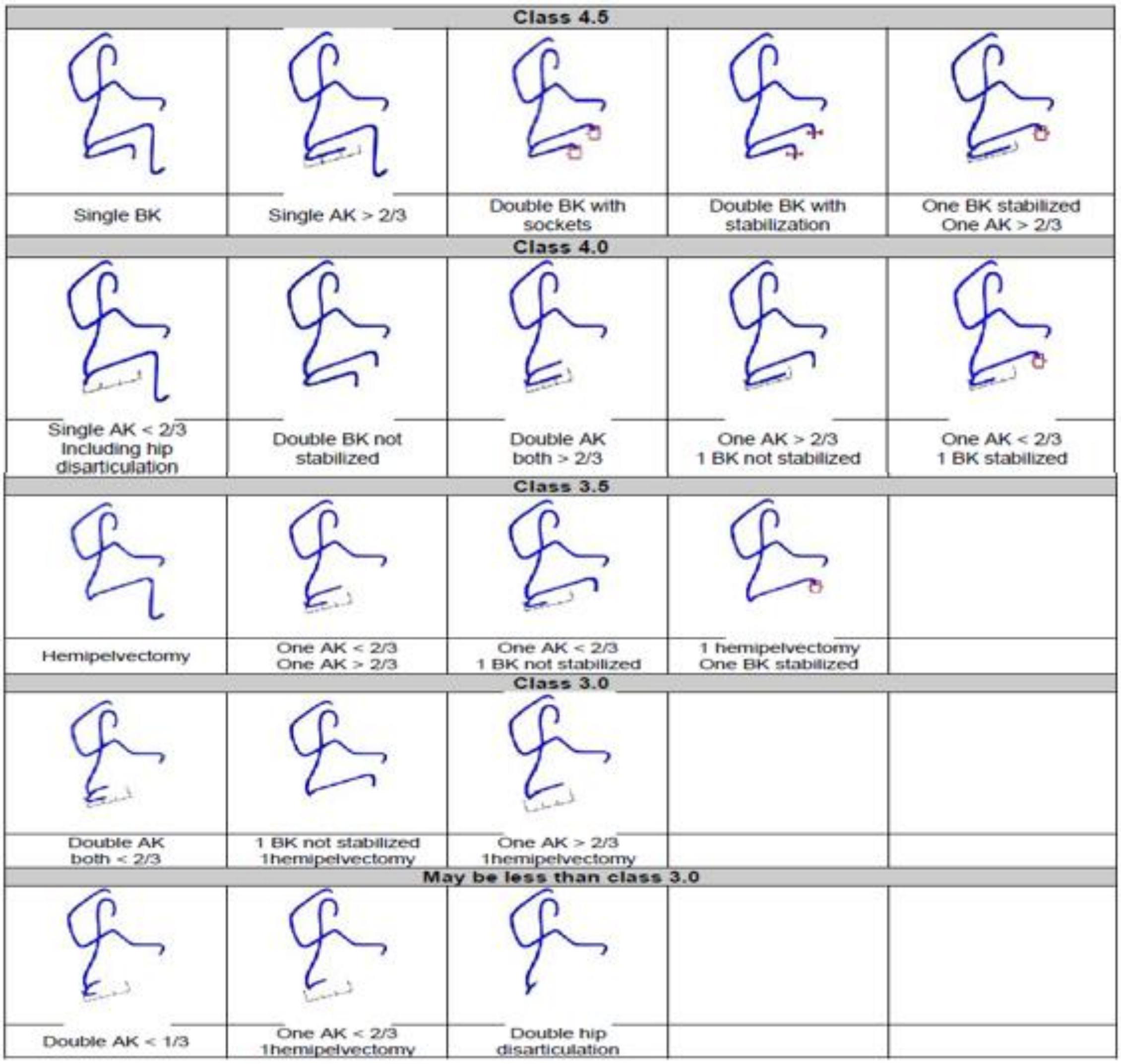

Figure 2.3 Classification of WB players with limb deficiencies (IWBF, 2021)

2.4 Shoulder pain in wheelchair basketball

Shoulder pain can originate from any of the structures of the shoulder joint. In WB, it has been associated with a number of pathologies commonly rotator cuff tear and injuries and impingement syndrome cause SP (Burnham et al., 1993; Lepera, 2010; Heyward et al., 2017). According to some studies, no relationship was established between SP and the type of disability even though spinal cord injuries or lesions and poliomyelitis were the most common disabilities in WB (Lepera, 2010; Christiana, 2019).

Shoulder pain has been reported to be prevalent in both dominant and non-dominant limbs (Soo Hoo et al., 2022) even though comparisons have not been made between these two. Christian (2019) reported SP to prevalent in both left and right upper limbs, with a study population that consisted of 60% right hand dominant and 40% left hand dominant WB players. De Witte et al., (2017) found that during rotational movements during offensive play, most players used the dominant limb for ball handling activities and the non-dominant one for moving the wheelchair. Perhaps the fact that both dominant and non-dominant limbs are used in activities that have been associated with SP may explain why SP in WB players is prevalent in both dominant and non-dominant limbs. The association between SP and limb dominance needs to be explored further.

2.4.1 Epidemiology of shoulder pain in wheelchair basketball

To establish the severity of a problem, incidence and severity of the said problem in the context being discussed should be established (Chalmers, 2002). While incidence rates have not yet been established in South Africa, the prevalence rates of SP reported in WB are generally high. Christiana (2019) in her study on shoulder pain and its risk factors among WB players in Johannesburg reported a point prevalence of 52% and a prevalence of 72% during wheelchair use. The high point prevalence may be explained by the fact that this study was conducted at the end of the basketball season. Lepera (2010) on the other hand found a point prevalence of 37.9% and 72.4% since the WB players began using a wheelchair. Lepera conducted her study just before the beginning of the WB season which could explain the differences in the point prevalence. While both studies were conducted among Gauteng based WB players, Mateus & Pillay (2019) may be a little more representative because their study involved WB players in the Supersport League games who are based from all over the country. The prevalence of SP since the start of their WB career was reported to be 54% and 44% in the previous twelve months (Mateus & Pillay, 2019). Wheelchair propulsion and overhead activities have been reported to aggravate SP the most (Lepera, 2010; Mateus, 2015). This is likely due to the fact that wheelchair propulsion places the humeral head in an impingement position while overhead activities are associated with high load on the shoulder joint (Lepera, 2010).

All the three studies above were cross sectional studies that used questionnaires that were validated and tested for reliability through experts and pilot studies. Cross sectional studies are the best for measuring prevalence (Portney & Watkins, 2015). They are however subject to recall bias. Their small sample sizes with the maximum being forty-eight WB players (Mateus & Pillay, 2019) were representative of the population under study and provide an insight into arguably the most advanced WB league in South Africa.

2.4.2 Risk factors associated with shoulder pain in wheelchair basketball

It is common knowledge that both high- and low-point players are at risk of developing SP (Curtis & Black, 1999; Lepera, 2010; Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016; Christiana, 2019; Mateus & Pillay, 2019). The intensity of pain and the mechanisms by which these two groups develop SP are what have been reported to be different. While some studies have reported that high-point players have higher intensity of SP (Curtis & Black, 1999; Christiana, 2019), others have established that low point players have more SP compared to high point players (Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016). It is unclear why there is a variation in the results. However, it is speculated that the difference in the timeframe when the research was conducted could be a contributing factor. For studies that were conducted during a WB season, high point players could report more SP since they carry most of the duties of the team. On the other hand, for studies that were conducted off season, low point players could report more SP due to their wheelchair use during daily activities and training (Lepera, 2010). However, this has not been explored immensely and may need to be researched further in the future.

In terms of the mechanisms that lead to development of SP, low point players are said to have high load on the shoulder from wheelchair use and transfers during training and basketball as well as their daily lives (Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016). On the other hand, high point players take more responsibility for ball handling activities including shooting and passing by virtue of their good strength in the trunk. Repetitive stress from the overhead activities associated with shooting and passing the ball may cause them to have SP (Yildirim, Comert & Ozengin, 2010). Regardless of the mechanism however, it is clear that both groups have a SP problem.

Several risk factors, intrinsic and extrinsic, have been associated with SP. Intrinsic risk factors include muscle imbalances, posture, range of motion and flexibility (Burnham et al., 1993; Curtis & Black, 1999; Lepera, 2010; Aytar et al., 2015). Extrinsic factors associated with SP in WB include years of wheelchair use and propulsion techniques. Improved mechanics of propulsion have been recommended for possible prevention of SP due to improper propulsion techniques (Lepera, 2010; Yildirim, Comert & Ozengin, 2010; Christiana, 2019).

Shoulder muscle strength imbalances have been mainly associated with WB players with low trunk control. Burnham et al (1993) found weakness of shoulder adductors compared to abductors in WB players. This pattern was reported to be different from swimmers and other overhead sports where shoulder adductors were stronger than abductors (Burnham et al., 1993). In addition to this, WB players have been associated with overuse and tear of the rotator cuff muscles as they are overworked in their role to stabilise the shoulder (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). When they get fatigued, the rotator cuff muscles fail to maintain humeral head in the glenoid fossa during motion of the shoulder. Because of the strength imbalance between shoulder adductors and abductors, there is an increased risk of the humeral head being pulled upward during motion. This superior translation of the humeral head may lead to impingement syndrome (Heyward et al., 2017). Pectoral muscles have also been reported to be much stronger than posterior shoulder muscles due to wheelchair propulsion (Curtis & Black, 1999; García-Gómez et al., 2019).

With regards to posture, due to reduced trunk and pelvic control, low point players sit in a wheelchair with the pelvis tilted posteriorly leading to compensatory hyper kyphosis of the thoracic spine, protraction of the scapula and forward movement of the shoulders and head. This causes posterior structures including scapular stabilisers to elongate and weaken, and structures on the front including pectoralis minor to shorten and tighten (Burnham et al., 1993; Curtis & Black, 1999; Aytar et al., 2015; García-Gómez et al., 2019). Furthermore, significant reduction in internal rotation (IR) range of motion (ROM) of more than fifty degrees and slight increment in external rotation (ER) ROM have been reported (Burnham et al., 1993; Curtis & Black, 1999; Wilroy & Hibberd, 2018; Christiana, 2019). This has also been associated with altered sitting posture resulting in tightening of anterior structures, reduced flexibility, and compensatory lengthening of posterior structures (Aytar et al., 2015). Interestingly, altered kinematics of the shoulder may also be as a result of a protective mechanism as the body chooses the movement patterns that will cause less pain (Briley et al., 2021).

2.4.3 Biomechanics of the shoulder joint

The mechanisms that lead to the development of SP among WB players can be partially explained through the biomechanics of the shoulder joint. In fact, in WB, SP has been associated with the structure and function of the shoulder joint itself. The shoulder girdle, unlike the pelvic girdle of the lower extremities, is structured to allow high amounts of mobility (Veeger & van der Helm, 2007). The ball and socket of the glenohumeral joint (GH) is made such that the head of the humerus is much larger than its articulating surface, the glenoid fossa. Figure 2.4 below illustrates this concept.

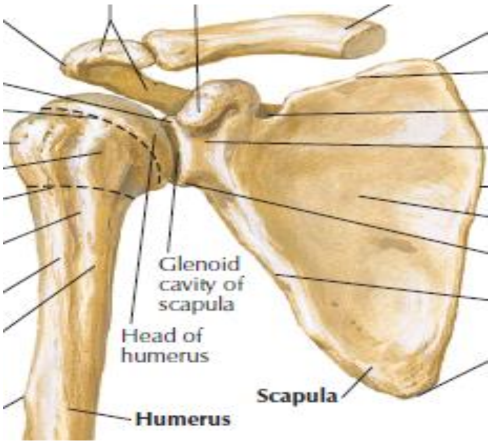

Figure 2.4 GH joint (Netter Frank, 2018)

High mobility of the shoulder joint is further explained by the loose connection of the scapula to trunk, making it able to slide and rotate on the rib cage during glenohumeral motion (Veeger & van der Helm, 2007). Scapula motion is said to be responsible for about a third of total elevation of the arm. During elevation as the humerus elevates, the scapular contributes to the movement by rotating laterally in a mechanism called the scapulohumeral rhythm (Fig 2.5 below) (Veeger & van der Helm, 2007).

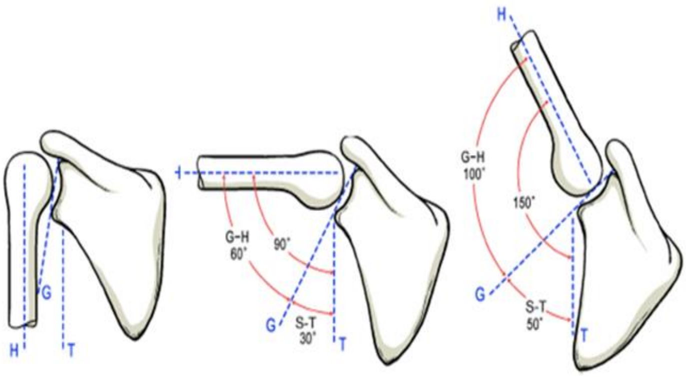

Figure 2.5 Scapulohumeral rhythm (Kovacevic, 2012)

WB players however, have been reported to present with scapular dyskinesis, where the scapular is translated laterally at rest (Aytar et al., 2015). This translation of the scapular at rest and a typical posture of posterior pelvic tilt, increased thoracic kyphosis and a forward head posture with an anteriorly displaced shoulder girdle in individuals that use a manual wheelchair in their everyday lives including sports, may lead to weakness of scapulothoracic muscles and shoulder pain (Aytar et al., 2015; Soo Hoo, 2019). On the other hand, this “typical” posture may also be brought about by weakness of scapulothoracic muscles (Aytar et al., 2015). Scapulothoracic muscles, especially the serratus anterior and rhomboid muscles, stabilise the scapula during forward flexion/elevation of the arm. When weakened due to altered scapular movement and position, they impact normal function on the shoulder. The serratus anterior is also the main muscle that generates torque (propulsive force) during elevation (Veeger & van der Helm, 2007). Repetitive sudden stops and pivoting during WB may lead to overuse of the serratus anterior leading to repetitive strain injuries (Wilroy & Hibberd, 2018; García-Gómez et al., 2019).

With all the mobility however, the shoulder joint is quite equipped for static and dynamic stability as well (Veeger & van der Helm, 2007). Because of its complexity, the shoulder has been recognised as a specialty within sports medicine (Wilroy & Hibberd, 2018). The rotator cuff muscles are important dynamic stabilisers of the shoulder joint, and they function to maintain the humeral head in the glenoid fossa during motion (Lugo, Kung & Ma, 2008; Rathi, Taylor & Green, 2016).

Experiments conducted on muscle activity during hand rim wheelchair propulsion show that the rotator cuff muscles, especially the supraspinatus, are active during the entire wheelchair propulsion cycle (Vanlandewijck, Theisen & Daly, 2001; Boninger et al., 2002). They are therefore prone to fatigue which could eventually lead to SP (Heyward et al., 2017).

Finally, because of the deficit in the kinetic chain with the lower body unable to assist in force production during manual wheelchair propulsion, the shoulder has to produce high propulsive forces (Heyward et al., 2017; Fairbairn & Bliven, 2019). Therefore, during the game, training and ADLs, the shoulder is repetitively overloaded leading to overuse of muscles (Heyward et al., 2017).

2.5 Biomechanics of wheelchair basketball

Biomechanics of WB provide insight into the load and mechanisms that may lead to shoulder pain among WB players, making it vital to address. This section will discuss general hand rim wheelchair propulsion biomechanics as it relates to WB and specific dynamics for WB, and the association between the biomechanics and SP.

2.5.1 Hand rim wheelchair propulsion biomechanics

Studies researching hand rim wheelchair propulsion have mostly been simulations of the task and its dynamics because it is difficult to study wheelchair propulsion biomechanics under real life conditions (Vanlandewijck, Theisen & Daly, 2001). However important information related to load and mechanisms on the shoulder have been discussed. In this review, only information from simulation studies that used a treadmill or dynamometer are included because they simulate close to real life as compared to a stationery ergometer (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

In WB, not all players use a wheelchair for daily activities. However, all players use a wheelchair for sports (Vanlandewijck, Theisen & Daly, 2001; IWBF, 2021) and so all players perform manual wheelchair propulsion at a certain level. In fact, some studies have reported that more 60% of a match consists of propulsive action (Vanlandewijck, Theisen & Daly, 2001; Seron, Oliveira De Carvalho & Greguol, 2019), hence the necessity for discussing this.

Hand rim wheelchair propulsion is a repetitive process, and the propulsion cycle consists of the push and recovery phases. During the push phase, a wheelchair user's hand makes contact with the rims of a wheelchair and apply propulsion force. The recovery phase is a phase when the user's hands are not in contact with the rims and are preparing for contact (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

Both the push and recovery phases are active phases, meaning that shoulder muscles are actively working in each phase. In the push phase, shoulder muscles are working to produce propulsive force. Shoulder flexors, anterior deltoid and pectoralis major muscles are said to be the prime movers in wheelchair propulsion. Other muscles that dominate this phase are external rotators, supraspinatus and infraspinatus muscles, and the serratus anterior muscle which is a scapular protractor (Vanlandewijck & Thompson, 2000; Van Der Woude et al., 2001).

On the other hand, the recovery phase is dominated by active shoulder extensors, posterior deltoid, abductors, medial deltoid and supraspinatus, internal rotator, subscapularis and scapular retractor, medial trapezius (Vanlandewijck, Theisen & Daly, 2001). Interestingly, push phase muscles are also active in the recovery phase for deceleration prior to impact and recovery phase muscles are active at the end of the push phase to prepare for the recovery phase (Vanlandewijck, Theisen & Daly, 2001).

Meanwhile, the rotator cuff muscles are said to be active during the whole propulsion cycle performing their stabilisation duty (Mulroy et al., 1996; Boninger et al., 2002). More importantly, they are active at a high level, close to their maximal capacity (Boninger et al., 2002; Desroches et al., 2010).

Apart from propulsive force, there are compressive forces acting the shoulder joint and torques produced or acting at the shoulder joint (Van Der Woude et al., 2001). Compressive forces acting at the shoulder could reach as high as 2000N. Unfortunately, research has not been able to establish the actual values of joint torques because that would require an invasive technique. However, large net joint torques are reported at the shoulder, indicating large muscle forces (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

2.5.2 Specific wheelchair basketball dynamics

The specific movement dynamics in WB include intense braking action, the ability to accelerate from standstill, pivoting and quick stops (Vanlandewijck, Theisen & Daly, 2001). Although these dynamics form less than 40% of the WB time, they are all very explosive movements and so require a lot of force from the upper body, specifically the shoulder. Even though they haven't been analysed further, 30 minutes of a WB game consists of about 34% braking action with 240 stops, giving it its high intensity intermittent characteristic according to a study by Seron, Oliveira De Carvalho & Greguo (2019).

According to Vanlandewijck, Theisen & Daly (2001), manoeuvrability of a wheelchair is dependent on seat heat height, shifts in centre of gravity (COG) and resistance from rolling friction of a moving wheelchair. A low seat height and a forward shift in COG allows for faster acceleration from standstill. Therefore, because low point players are unable to actively move their trunk forward, they tend to maximise their speed by choosing a low seat position while high point players can move their trunk forward at will, so they tend to choose a high seat position. This is also because high point players take on scoring duties on the team and low point players take on defensive duties (Vanlandewijck, Theisen & Daly, 2001).

2.5.3 The Role of wheelchair basketball biomechanics

Wheelchair propulsive force is solely created by muscles of the shoulder girdle (Boninger et al., 2002) and moderate propulsive force is created during standard wheelchair propulsion on level surface (Van Der Woude et al., 2001). During WB however, because of the dynamics of the sport like acceleration from stand still and pivoting these forces can get extremely high.

This in turn causes high resultant forces on the shoulder (Vanlandewijck, Theisen & Daly, 2001). Veeger & Van del Helm (2007) report that the compression force in the shoulder joint may get as high as 2000N. These extremely high compression forces and the repetitive action of wheelchair propulsion and its dynamics strains the shoulder and this may lead to overuse and pain (Vanlandewijck, Theisen & Daly, 2001; Veeger & van der Helm, 2007; Heyward et al., 2017).

In addition to this, the propulsive forces applied on the hand rim are non-tangential in their direction. This in itself may not be an issue because it ensures that the mechanics of the upper limb do not respond in unusual patterns since the propulsive force is generated during a closed chain movement (Van Der Woude et al., 2001). Figure 2.6 illustrates this.

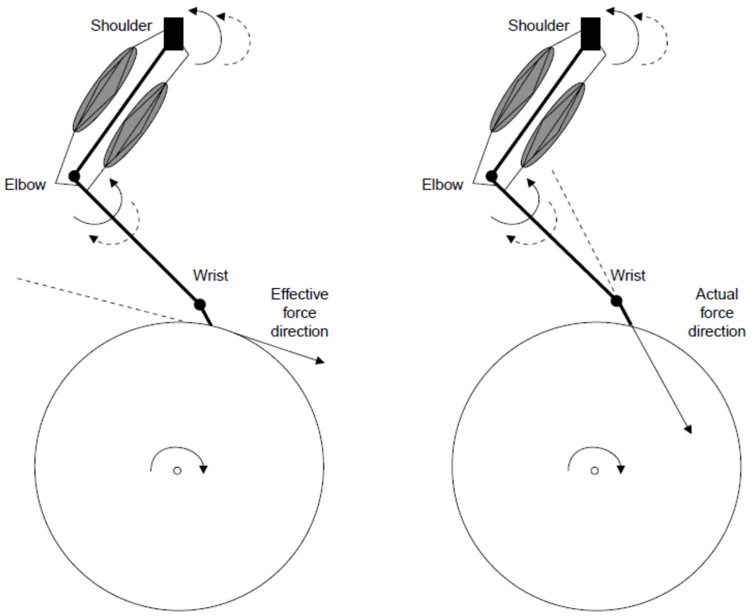

Figure 2.6 Effective vs actual direction of propulsive force (Vanlandewijck et al, 2001)

On the left in figure 2.6 above, with the effective force direction, the elbow would have to move into elbow extension while an elbow flexion moment is required. This would impact the mechanics of the rest of the upper limb joints, including the shoulder (Veeger & van der Helm, 2007). Due to the improper mechanics of the shoulder, shoulder muscles would have to work harder to stabilise the joint leading to high mechanical load. This would lead to possible injury of shoulder joint cartilage or muscles (Van Der Woude et al., 2001). Because wheelchair propulsion is a closed kinetic chain movement though, the actual force direction then tends to be non-tangential as shown on the right side in figure 2.6 (Veeger & van der

Helm, 2007). However, during repetitive strokes, Boninger et al (2002) discovered that there are impact strikes due to the non-tangential direction of force applied to the hand rim. These impact strikes may induce trauma to soft tissue structures of the upper limb including the shoulder.

Apart from propulsive force, there are torques being produced at the shoulder during propulsion. These torques can provide an indication of the forces needed at the GH joint during this time. Studies have only been able to calculate net torques over individual muscle torques (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001). Because of the need for stability at the GH joint, net torques may be an underestimation of the total forces since antagonist muscles are active as well. This means that sometimes the torques can cancel each other out, producing a net torque of zero when the forces are not zero (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

Among WB players, a dominant external rotation and abduction moment was reported during submaximal wheeling (Vanlandewijck, Theisen & Daly, 2001). However, during acceleration from standstill, forward flexion of the trunk leads to internal rotation of the shoulder, with the external rotators working eccentrically. A situation of repetitive internal rotation position with high external rotator and abduction load is a risk factor for impingement of the supraspinatus muscle (Vanlandewijck, Theisen & Daly, 2001). In addition, high ER compared to IR moments, and high abduction compared to adduction moments are a risk factor for muscle imbalances leading to the subsequent weakness of adductors to abductors and internal rotators to external rotators (Vanlandewijck, Theisen & Daly, 2001; Desroches, Aissaoui & Bourbonnais, 2008; Soo Hoo, 2019).

2.5.3.1 The throwing shoulder

Overhead activities in people with disabilities have been associated with increased load on the shoulder and therefore increased risk of rotator cuff tears (Akbar et al., 2015). High point players are most likely to be affected by this because they take on shooting duties for the team (Vanlandewijck, Theisen & Daly, 2001; Yildirim, Comert & Ozengin, 2010).

Repetitive overhead position has been associated with altered scapular kinematics (Wilroy & Hibberd, 2018; Demeco et al., 2022). Demeco et al., (2022) found that the scapular on the dominant side had reduced upward rotation during a kinematic assessment of WB athletes. This was owed to repetitive overhead position and activities. This reduction in scapula rotation during GHJ movement leads to a reduced subacromial space leading to impingement of the shoulder.

2.6 Prevention of shoulder pain in wheelchair basketball

Few studies have discussed ways to prevent shoulder pain in wheelchair basketball players (Curtis & Black, 1999; Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019; Lee, McKay & Gutierrez, 2020). Strengthening exercises may be useful in the prevention of SP in WB players but a balance must be found between exercising the shoulder and overuse (Heyward et al., 2017). Stretching and range of motion exercises have also been recommended by a few studies (Wilroy & Hibberd, 2018; García-Gómez et al., 2019).

Wilroy and Hibberd (2018) in their study adapted a six-week programme that was previously used for swimmers to improve characteristics associated with SP in college WB players in a pre and post-test study. The programme focused on improving internal and external rotation ranges of motion and the strength of subscapularis, infraspinatus and teres minor, scapular stabilisers and trapezius muscles. Strengthening exercises were conducted using resistance bands with progressive resistance for the first three weeks and then repeated with different number of repetitions the final three weeks. Static stretching was incorporated as part of the program to combat tightness of pectoralis minor muscle (Wilroy & Hibberd, 2018).

A non-randomised clinical trial evaluated a ten-week exercise programme to improve SP and maintain shoulder function (García-Gómez et al., 2019). Unlike Wilroy and Hibberd (2018), this programme included warm up and cool down exercises which have been associated with SP (Lepera, 2010) and have been recommended in prevention of sports injuries (Henke et al., 2017). Like Wilroy and Hibberd (2018), the programme included strengthening exercises using resistance bands and stretching exercises. This study included strengthening exercises for scapula retractors and depressors, shoulder rotators and adductors, and serratus anterior which is a scapular protractor and stabiliser. Stretching exercises included pectoral muscles and other muscles. This study covered a lot more factors that have been associated with shoulder pain in WB players compared to the study by Wilroy and Hibberd (2018).

Because both exercise programmes were to be conducted at home, the players were given logs where they could fill in the date and exercises conducted. García-Gómez et al (2019) followed this up with reminders through emails and phone. The athletes were also given pictures that demonstrated how each of the exercises were done in both studies. This however does not completely take the chance of the exercises not being conducted appropriately or not being conducted at all.

Though incidence of SP was not measured or reported on, Wilroy & Hibberd (2018) report that their strengthening and stretching program may reduce risk factors associated with SP among WB players. The study by García-Gómez found that even though SP and strength did not improve after ten weeks of the exercise programme, shoulder function was maintained, and the WB players did not develop SP during competition. Both of these studies have brought about important contributions as far as prevention of SP in WB players. However, they have both not measured the incidence of SP post their respective interventions which would provide a direct measurement for the effect of their programs on development of SP.

Internal and external rotation ranges of motion improved by eleven and eight degrees respectively at the end of the six-week exercise programme (Wilroy & Hibberd, 2018) while there was no significant improvement in the ROM in the ten-week programme (García-Gómez et al., 2019). A study conducted on competitive swimmers who also develop tightness of the pectoralis minor suggested considering the use of muscle energy techniques to stretch pectoralis minor. Muscle energy techniques have been proven to increase flexibility more than static stretching (Laudner et al., 2015). In their study, Wilroy & Hibberd (2018) were not able to assess scapular position before and after intervention due to limitations in posture assessment for wheelchair users even though scapular stabilisers were targeted in the programme. However, the programme had shown to cause improvements in posture of swimmers (Kluemper, Uhl & Hazelrigg, 2006).

There was no improvement in muscle strength however (Wilroy & Hibberd, 2018). WB players may undergo intense strength and conditioning programmes with their coaches and trainers that perhaps strengthening using resistance bands may not be adequate (Wilroy & Hibberd, 2018). One such programme is located in the strength and conditioning philosophy document for British WB players where strengthening exercises of intensity as high as five rep max (repetition maximum) are found (Jarvis, 2009).

A study by Burnham et al (1993), reports that shoulder muscles of WB players may be even stronger than able-bodied athletes due to the high loads constantly placed on the shoulder for wheelchair use and basketball. While literature recommends strengthening of shoulder muscles, an emphasis must also be placed on muscle imbalance since that is the known problem as opposed to strength alone. Both studies by Wilroy and Hibberd and García-Gómez et al work on strengthening of shoulder muscles. While Wilroy & Hibberd (2018) had strengthening exercises for scapula thoracic muscles, their programme did not include strengthening of shoulder adductors which are necessary to strengthen considering that abductor/adductor strength imbalance is a big risk factor for SP among WB players. However, García-Gómez et al (2019) made sure to include them in their programme. A holistic programme should be able to carter for all the muscle imbalances.

The strength and conditioning philosophy for Great Britain WB athletes suggests that it may be necessary to work on corrective exercises for posture before proceeding to strengthening and of course maintenance (Jarvis, 2009). Scapula protraction is a prominent feature in WB players (Burnham et al., 1993; Curtis & Black, 1999; García-Gómez et al., 2019) such that it may be necessary for the exercises to target it more and not just as part of a strengthening programme.

Wilroy and Hibberd (2018) adapted an exercise programme that was previously reported to work for competitive swimmers. The pattern of muscle imbalance has been described to be different in WB with shoulder adductors being weaker than abductors compared to swimmers who have weaker abductors than adductors (Burnham et al., 1993). The study however did a pre-test evaluation where they found that the WB players in their study presented with similar physical characteristics with other overhead sports. Their pre-test evaluation however focused on assessment of strength of internal and external rotators of the shoulder and scapula stabilisers as opposed to adductors and abductors of the shoulder.

Literature has reported differences in the mechanisms that may result in SP for WB players with high class and low class IWBF ranks (Curtis & Black, 1999; Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016). Mateus and Pillay (2019) in their dissertation suggest that point classification of WB players be considered when addressing issues concerning WB. Player position and role in the team have also been suggested to be considered when thinking about injury prevention for WB players (Lee, McKay & Gutierrez, 2020). Yet the studies addressing prevention of shoulder pain above conducted the same exercises for all the participants of the studies regardless of their classification and role in the team or playing position.

Christiana (2019) in her study on SP and its risk factors in WB players in Johannesburg identified IR ROM and instability as risk factors associated with SP. Instability has not been addressed directly in the studies that have looked at prevention of shoulder pain among wheelchair basketball players. They partially address it by strengthening the rotator cuff muscles but large shoulder adductors like latissimus dorsi and pectoralis major have been known to assist in stabilisation of the shoulder by opposing upward pull of the humeral head by the deltoid muscle (Veeger & van der Helm, 2007; Lugo, Kung & Ma, 2008).

2.7 Wheelchair basketball versus other sports

According to Aytar et al (2015) shoulder pain and scapular dyskinesis was worse in WB compared to amputee soccer and disabled tennis. While SP and abnormal scapular positioning are associated with repetitive hand rim propulsion and overhead activities, in disabled tennis it was associated with repetitive use of the upper limbs at and above shoulder level, trunk movements and shortening of neck and anterior muscles of the shoulder girdle (Aytar et al., 2015). For amputee soccer SP was associated with crutch usage.

In overhead sports, while SP is also prevalent, the pattern of muscle imbalance varies. Among WB players, there is stronger abductors compared to adductors while the opposite is true in overhead sports (Burnham et al., 1993). Wilroy & Hibberd (2019) however reported swimmers presenting with the same functional deficits as WB players. However, the study only discussed scapular dyskinesis, GHJ ROM and weakness of shoulder muscles in general.

2.8 Review of research articles included in review

The articles included in this literature review on prevalence and risk factors have all been cross sectional studies. Cross sectional study design is a good methodology for prevalence studies (Lepera, 2010; Robinson, 2011). The studies also addressed issues of pain intensity and classification of players which is good. They also used instruments with high validity and reliability with clearly presented outcomes. For the studies in South Africa, the instruments were even adapted to suit the conditions locally. Most of the studies had a lot of items on the STROBE checklist well covered making them high quality studies even though observational studies are not the highest level of evidence on the evidence pyramid (Murad et al., 2016).

Some of the studies had big samples (Burnham et al., 1993; Curtis & Black, 1999) while some of the studies had small samples. The studies conducted in South Africa especially had small samples with the maximum a little below fifty participants (Lepera, 2010; Christiana, 2019; Mateus & Pillay, 2019). These small sample sizes may not be representative of the country.

Studies on prevention of SP are few generally (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). These studies focused on a lot of factors associated with SP in WB. García-Gómez et al (2019) even conducted her study in multiple stages involving developing an exercise programme that was unique and then validated through expert opinion in a Delphi study which they then went on to evaluate (García-Gómez et al., 2017). The studies were non-randomised trials which is less preferred because of issues of bias. When conducted well for topics that have scarce information, non-randomised trials can still be considered high level of evidence (Murad et al., 2016).

Similarly, the biomechanical studies found were mostly non-randomised experimental studies. Some of these studies were conducted well while others had smaller sample sizes and had limitations with their instruments. In this regard, the quality of evidence was variable. Review articles found were mostly non-systematic with one critically appraised topic study.

2.9 Conclusion

This chapter discussed shoulder pain and its prevention among wheelchair basketball players. There has been a lot of research on SP in WB especially in the epidemiology of it. Few studies have been conducted on the prevention of SP in WB players and in my knowledge, none taking into account classification of the players and none in South Africa. This study will add to much needed literature in prevention of Shoulder pain in wheelchair basketball.

Chapter 3 Methods

This study is a mixed methods study that began with a scoping review followed by a modified Delphi study. For this reason, this chapter is presented in two parts following the study process. The first part will present the methodology for the scoping review and the second part will present the Delphi study methodology.

3.1 Part one: scoping review methods

3.1.1 Aim

A scoping review was conducted to map out the range of preventive strategies for shoulder pain or injury in wheelchair basketball and wheelchair sports.

3.1.2 Study design

A scoping review was conducted according to frameworks by Arksey and O'Malley (Arksey & O'Malley, 2005) and the Joanna Briggs Institute (JBI) methodology of scoping reviews (Pham et al., 2014; Tricco et al., 2016). The steps are outlined below.

3.1.3 Identifying research question

In the first step of the scoping review, a research question was defined by the researcher, using the Population Concept Context (PCC) framework (Tricco et al., 2016) as follows: "what exercises are known in literature to prevent shoulder pain among WB players?"

The PCC framework is a method recommended by JBI which is used to define the specific elements of a research question for a scoping review and informs the inclusion criteria (Peters et al., 2015). It clearly states that the research title/question should be brief but comprehensive enough to reflect the population, concept and context of the review as these inform the inclusion and exclusion criteria (Peters et al., 2015).

For this scoping review, the study population are all WB players or wheelchair sports athletes, regardless of sex, gender, age, level of play, classification, etc., because they all could be at risk for developing shoulder pain.

The main concept being examined in this review are exercise-based prevention strategies for shoulder pain in WB or wheelchair sports.

Finally, to map out the range of evidence available, the context of the study was studies across the world and not just limited to South Africa. The review would also consider all prevention programmes whether home-based or not.

3.1.4 Identifying and selecting relevant studies

Three main databases namely PubMed, Scopus and EbscoHost, were searched from 21st to 25th of March 2021 by the researcher and a research assistant as recommended by JBI protocol for conducting a scoping review (Tricco et al., 2016). CINAHL, Medline (Complete) and Sport Discus were included in the EbscoHost search. Search terms used were "Shoulder pain" OR "shoulder injury" AND "wheelchair basketball" OR "wheelchair sport" AND "prevention" OR "treatment" OR "program" OR "exercise". The search strategy (Appendix I) was developed with the assistance of an experienced Librarian, with an example for PubMed provided in the figure below. The rest of the databases followed the same structure.

Table 3.1 Search strategy

Database: Medline via PubMed Restriction: English Language Terms were searched for in "Textword and MeSH", where possible Search 3: ("shoulder pain"[Text Word] OR "shoulder injury"[Text Word] OR "shoulder joint/injuries"[MeSH Major Topic]) AND "wheelchair basketball"[Text Word] AND ("prevention"[Text Word] OR "intervention"[Text Word] OR "program*"[Text Word]) Retrieved: 4 articles

Titles and abstracts were screened followed by a review of full text articles. Reference lists were then scanned for the possibility of identifying new articles. All three processes were conducted by the researcher and research assistant independently and then discussed in a briefing meeting.

Only articles published in English were included to save time and translation costs. Studies that recommended or discussed a specific type of exercise were included in keeping with the aim of the review. Studies that discussed prevention of SP using other strategies except exercises were excluded as they were not answering the question of the review. In addition to this, studies that addressed exercise-based prevention strategies in regular overhead sports were excluded because the pattern of muscle imbalance/weakness in overhead sports is slightly different compared to WB. Finally, studies that discussed shoulder pain prevention in paraplegics that did not participate in any sports were also excluded.

3.1.5 Data Charting

After relevant studies were selected, information including the study characteristics and the intervention or exercise program was collected and summarised in a data chart.

3.1.6 Collating, summarising and reporting the results

Exercises identified from the outcome of the scoping review were categorised into strengthening, mobility, stretching and other exercises (García-Gómez et al., 2017). Using the Frequency, Intensity, Time, Type (FITT) principle of exercise prescription (Riebe et al., 2018) and presented in a table format. The scoping review took a period of six weeks in total.

3.2 Part two: Delphi methods

This section is discussing the methodology used in the Delphi study, the second phase of this mixed methods study.

3.2.1 Study design

A consensus development study using a modified Delphi study was conducted in three rounds. In a modified Delphi, instead of ideas being generated from open ended statements as in the first round of a classical Delphi, ideas are generated from a literature review or a focus group or through interviews (Keeney, Hasson & Mckenna, 2011). In this research, the first round was replaced by a scoping literature review.

3.3 Study setting

This study took place entirely online, with emails sent for communication with participants and questionnaires completed via RedCap.

3.4 Participants

3.4.1 Source of participants

Participants included in this study were selected from recommendations made by other professionals including lecturers and physiotherapists who were aware of their suitability for the study and their involvement in sports. Then the recommended members were sent an invitation to participate in the study through email. The email also included an information sheet (*Appendix II*) explaining the study procedure and purpose, a link for first round questionnaire (*Appendix III*) to be completed via RedCap and a summary of the scoping review findings. A written consent form (*Appendix 1V*) formed the first part of the questionnaire. Participants were only allowed to proceed with the rest of the questionnaire upon providing written consent and their signature.

3.4.2 Sample size

According to Grime and Wright (2016), there is no recommended standard of calculating the number of experts that form a Delphi panel even though a sample of 5-20 panel members is recommended. This study comprised of six Delphi panel members.

3.4.3 Sample selection

Convenience sampling method was used to recruit experts for this study. In total 14 emails were sent out to potential participants inviting them to participate in the study. This phase took three weeks, allowing the potential participants to make a decision.

3.4.3.1 Inclusion criteria

The panel included physiotherapists, biokineticitists and sports scientists that are

i. Male and female with a minimum of a bachelor’s degree in their respective field.
ii. Currently involved in wheelchair basketball, basketball, and overhead sports for two years or more by the time of the research in any capacity either as team therapist or treating WB players as out-patients.
iii. Registered with Health Professions Council of South Africa (HPCSA) or their respective council.

3.4.3.2 Exclusion criteria

i. Not practicing in Southern Africa

3.5 Instrumentation and outcome measures

3.5.1 Round one questionnaire

Following completion of the scoping review, exercises identified were compiled into a questionnaire for the first round (*Appendix III*) using FITT format of exercise prescription (Riebe et al., 2018) and rated using a five-point Likert scale from strongly disagree to strongly agree. The third option, modify, had a space allocated for participants to state their recommended modification(s) to the particular exercise.

This questionnaire was formed using the draft from Keeney, Hasson and Mckenna (2011) and reviewed by a professional Physiotherapist and lecturer before it was sent to three participants in a pilot study. This draft was selected due to its ease of use. Once completed, the questionnaire was modified by correcting few misspelt words and including a summary of the study process before the Delphi and the purpose of the study as an introduction**.**

The exercises in the questionnaire were categorised into four main sections including warm-up, strengthening exercises, scapular stabilisers activation and cool-down. Each exercise consisted of its dosage following the FITT format of exercise prescription (Riebe et al., 2018) and its progression throughout the length of the program which was set for nine weeks.

The warm-up section was further subdivided into two phases, one and two. The first phase contained four exercises of active movements of the shoulder and the goal was to encourage mobility and flexibility of the shoulder. The goal of the second phase of warm-up was to encourage correct movement patterns and it consisted of three functional exercises.

The second section of the exercise program was made up of seven strengthening exercises of the shoulder, including external rotation (ER) and internal rotation (IR), serratus anterior, biceps curls, scapular depression and abduction, scapular retraction, and shoulder adduction strength. The third section consisted of two exercises for activating scapular stabilisers and the final section, cool-down, was made up of four stretching exercises for the pectoralis major and minor muscles, upper trapezius and levator scapulae, posterior capsule, and internal and external rotators of the shoulder.

3.5.2 Round two questionnaire

Round two questionnaire (*Appendix V*) was compiled from exercises that reached a median score of three but did not reach a consensus agreement of 80% from the first round.

Recommendations made and a summary of the results from the first round were added to the questionnaire. The table below shows the format for the questionnaire in the second round.

Table 3.2 Excerpt of second-round questionnaire

Exercise	Feedback Summary	Your Previous Response	Recommended Modification(s)

3.6 Procedure

3.6.1 Pilot study

Exercises from the scoping review were compiled into a questionnaire which was then reviewed and revised by the researcher and the supervisor before it was sent out to three physiotherapists that were selected through convenience sampling method. One of them fit the inclusion criteria for the study while the other two did not. Of the two that did not fit the inclusion criteria, one had only worked with WB players for six months while the other had not worked with WB for more than three years. The aim of the pilot study was to ensure that the questions on the questionnaire were clear and concise and to check for misspelt words and make corrections. In addition to this, the pilot study was conducted to refine the questionnaire if necessary and to test for data analysis techniques. The pilot study also allows the researcher to check for ambiguities (Skinner et al., 2015). Therefore, for the purpose of this pilot study, the participant characteristics were acceptable.

Once the three participants responded to the questionnaire, a summary of their feedback was made. One participant on commenting on internal and external rotation of the shoulder procedure in the warm-up said, “What is meant by stabilised to body by a resistance band? However I understand this involves IR/ER at the shoulder.” Also, three misspelt words were identified and corrected. Following this, the questionnaire was modified by correcting the misspelt words clarifying the procedure.

Once this was completed, one of the pilot study participants was included in the main study because they qualified to participate in the main study.

3.6.2 First round

Upon completion of the scoping review, a 9-week exercise program was compiled, informed from literature discovered in the scoping review, grey literature (Jarvis, 2009), and the researcher's three year experience working with wheelchair users. This program was arranged into four sections including warm-up, strengthening exercises, scapula stabilisers activation and cool down phases. Each exercise had a description of the position it would be conducted in, the procedure of the way the exercise should be conducted, a prescription using the FITT principle and the way the exercise would be progressed. A brief summary of SP among WB players and the findings from the scoping review was presented and together with the exercise program formed the first-round questionnaire.

Expert panel members were then contacted via email and were asked to vote for each exercise using a 5-point Likert scale from strongly disagree to strongly agree. An information sheet explaining the study process was provided in the email to all the potential participants. Upon provision of consent, panel members were allowed to proceed and rate each exercise on a 5-point Likert scale on from strongly disagree to strongly agree. If they chose the third option, modify, they were allowed to suggest modifications to the exercise they thought needed modifying.

The voting process took three weeks even though originally planned for two weeks due to the low response rates in the first round.

3.6.3 Second round

All exercises that had a median score of ≥3 but did not reach a consensus agreement of 80% during the first round, were carried over to the second round. In addition to this, a column with quantitative and qualitative feedback from the first round was provided on each exercise. This allows experts to reflect on their views taking into consideration the contribution of the other members of the panel. However, the downside of this feedback process could be that panel members may alter their views just to be line with others (Barrett & Heale, 2020). Another column for their previous response was also provided. To provide the experts with comprehensive feedback, common themes per phase were provided in the questionnaire and a separate summary sheet of descriptive statistics (*Appendix VI*) was provided as well.

Panel members were then provided with three options: to maintain their previous response, or to change their response for the same exercise as it was in the first round, or to select modifications to be made from the recommendations. The questionnaire would then proceed depending on their choice. If the member chose to maintain their previous response, they were allowed to proceed to the next exercise. If they chose to change their response, a Likert scale as in the first round would appear. The third option, which was to modify, was changed to neutral in this case. Lastly, if they chose to select modifications, recommended modifications would appear. Members were allowed to select one or more modifications depending on whether the modifications would go together or not. For example, if two modifications were both recommending increasing dosage but with different numbers of repetitions, then participants were only allowed to select only one of them. On the other hand, if the modifications were addressing different aspects of the exercise, then participants were allowed to select as many modifications as they deemed fit.

3.6.4 Third round

An hour-long consensus meeting was conducted virtually using zoom. Participants were sent links for the meeting apriori with instructions to log in using their participant numbers which were provided to them in the second round. They were also instructed to turn off their videos. To ascertain anonymity, participants were all put in the waiting room before the start of the meeting so that the facilitator would change their names to participant numbers in the case that the name still appeared. Furthermore, the meeting was conducted in focus modification which ensures that members of the meeting are unable to see each other's video even if a participant turned on their video by mistake.

The aim and procedure of the meeting were explained to panel members in the beginning of the meeting using a PowerPoint presentation (*Appendix VII*). Then panel members were asked for permission to record the meeting for purposes of the research. Once permission was provided, the meeting was recorded, and the researcher only facilitated the discussion to ensure that the aim of the meeting was being followed and that all panel members were given a chance to communicate. A summary form (*Appendix VIII*) of the second-round feedback which was provided to the panel members before the meeting was used to provide visual input of the discussion.

3.6.5 Defining consensus

A consensus of 51% to 85% is generally acceptable (Keeney, Hason and Mckenna, 2011). According to a systematic review conducted by Diamond et al., (2014), a consensus of 80%

was more common. Therefore, for the purpose of this study, consensus was determined by an agreement rate of 80% or more.

3.6.6 Enhancing response rates

Prior to commencement of the study, experts were made aware of the study process through an information sheet (Keeney, Hasson & Mckenna, 2011; Toma & Picioreanu, 2016) and a sense of ownership was encouraged (Keeney, Hasson & Mckenna, 2011) by allowing experts to make modifications to exercises in the first round.

Communication was maintained by sending of appreciation messages upon completion of a questionnaire and reminders before completion. Responses were being tracked on RedCap and reminders were sent via email to participants that had not yet completed the questionnaires. The first reminder was sent five days after the questionnaire was sent. Then a second reminder would be sent after another five days. For participants that were still yet to respond, a phone call would be made to remind them.

Lastly, rounds were kept short requiring fifteen to thirty minutes to complete a questionnaire. In addition to this, feedback from the first and second rounds was sent to all the panel members.

3.6.7 Managing dropouts

Dropouts prior to the first round were considered not to affect the study and the expert was replaced (Toma & Picioreanu, 2016). Following the first round, one expert was lost to follow-up and so five experts participated in the second round. In the third round, one expert was also lost to follow-up while one expert had an emergency on the day of the meeting. The final round was completed by three members of the panel. These dropouts have been considered to have affected consensus and reported in the discussion and results (Toma & Picioreanu, 2016).

3.7 Ethical considerations

The study was approved (Appendix IX) by the Human Research Ethics Committee (HREC) at the University of Witwatersrand. Privacy and anonymity were maintained throughout the Delphi process. Participants were referred to using codes in the second and third rounds, when providing feedback and during the virtual meeting. Participants were asked to change their participant id to their participant number on zoom for the purpose of this project.

Informed consent sheets were only viewed by the researcher. To maintain anonymity of the participants, only the researcher had access to the demographic and consent information of the participants. Two research assistants who were assisting with coding the research data during content analysis were only given access to the questionnaires without the demographic and consent information.

3.8 Data analyses

Data was analysed using SPSS version 18.0 (SPSS Inc., Chicago, IL) and Microsoft excel. Descriptive statistics were analysed and compiled. Frequencies were calculated for each exercise to check for consensus. The table below provides a summary of the descriptive analysis.

Table 3.3 Descriptive statistics

Objective	Expected Outcome	Type of Variable	Analysis
To obtain experts' consensus on exercises to be included in the prevention programme.	Likert scale variables Strongly disagree, Disagree, Modify, Agree, strongly agree	Ordinal	Descriptive statistics: Frequencies (%) Median Interquartile range
To conduct a scoping literature review on current preventive strategies for shoulder pain in overhead sports	Authors, year of study, type of study, exercise-based intervention and recommendation	Categorical	Descriptive statistics: Frequencies (counts/numbers)

Recommended modifications were analysed qualitatively using content analysis. Statements to be analysed came from recommended modifications to exercises if the participant chose to modify the exercise. Content analysis was done with a directed approach, from previous literature on the topic gathered during the scoping review and a narrative review (Neuendorf, 2019). Data analysis was conducted by the researcher and two research assistants (a co-coder) for trustworthiness. None of these research assistants was involved in the scoping review.

In the first step, familiarisation of data was done by reading and re-reading data multiple times. On the third attempt, short notes were jotted down during the process of reading the data. Notes were written for every exercise, describing how every participant responded to an exercise. Then the general impression for each section of the program, warm-up phases one and two, strengthening exercises, scapular stabilisers activation, and cool down, for each participant was written down.

Following familiarisation, all recommended modifications per exercise were written down on a separate sheet of paper without developing initial codes. Then each modification was broken down into simple statements, keeping the wording of the writer the same. See figure below for further details.

WARM-UP, PHASE 1, EXERCISE 1 (WU 1.1)
Arm Circles

Recommended Modifications

Participant 09
"Start arm circles with flexed elbows and remind the players to set their scapula down and slightly wide for exercises. I would either change abduction to a PNF pattern or add shoulder flexion as well."

Participant 12
"The long axis of the extended arm may add strain to some with existing injury or pathology. As an initial warm-up, I'd suggest this with elbows flexed and only done with elbows extension once warmed up

Participant 09
1. *Start arm circles with flexed elbows.*
2. *Remind the players to set their scapula down and slightly wide for exercises.*
3. *I would either change abduction to a PNF pattern or add shoulder flexion as well."*

Participant 12
1. *The long axis of the extended arm may add strain to some with existing injury or pathology.*
2. *As an initial warm-up, I'd suggest this with elbows flexed and only done with elbows extension once warmed up*

Figure 3.1 Excerpt from qualitative data analysis

After breaking down the statements, action words were highlighted, with common actions highlighted in the same colour. Upon completion of this, initial codes were developed, derived from participant's original words and some additional codes that were not in the original words of the participants. Then initial codes were developed with reference from literature included in the scoping review. Some codes were kept in the original words of the participants while others were not. Following initial coding, a debriefing meeting was conducted to encourage trustworthiness by removing researcher bias. Then, the codes were grouped into four categories based on the four dosage parameters of the FITT principle and one miscellaneous category for other codes that did not fit into any of the four categories. See table below.

Table 3.4 Data analysis matrix

Exercise				
	Altering the procedure of an exercise	**Altering the type of exercise**	**Altering dosage of an exercise**	**Changing sections**
	Position of exercise	**Strength endurance** **Pure strength** **Activation**	**Intensity** **Frequency** **Repetitions**	**New section** **Warm-up**

On reporting to the panel members during provision of feedback, recommended modifications were reported in almost exact wording of the participant who recommended them. Abbreviations were expanded for example a participant used HBB for Hands behind the back. This abbreviation was reported as Hands behind the back during the feedback process. Modifications that were similar but had different wording were reported using one of the recommendations' words or were combined using developed codes and categories, keeping the meaning the same.

3.9 Conclusion of methodology

This chapter outlines the methods used in this study. The study design, aims, and the way data has been analysed has been discussed in this chapter. Ethical considerations have also been outlined clearly.

Chapter 4 Results

4.1 Introduction

This chapter outlines the results for this study. The articles included in the scoping review, consensus and other descriptive statistics in the first to the third rounds will be presented.

4.2 Scoping review

4.2.1 Description of studies

From the initial search, 127 articles were identified.. After, removal of duplicates, 117 articles went through the screening process. Eventually, only five articles met the inclusion criteria. The figure below is the evaluation flow chart detailing the research process.

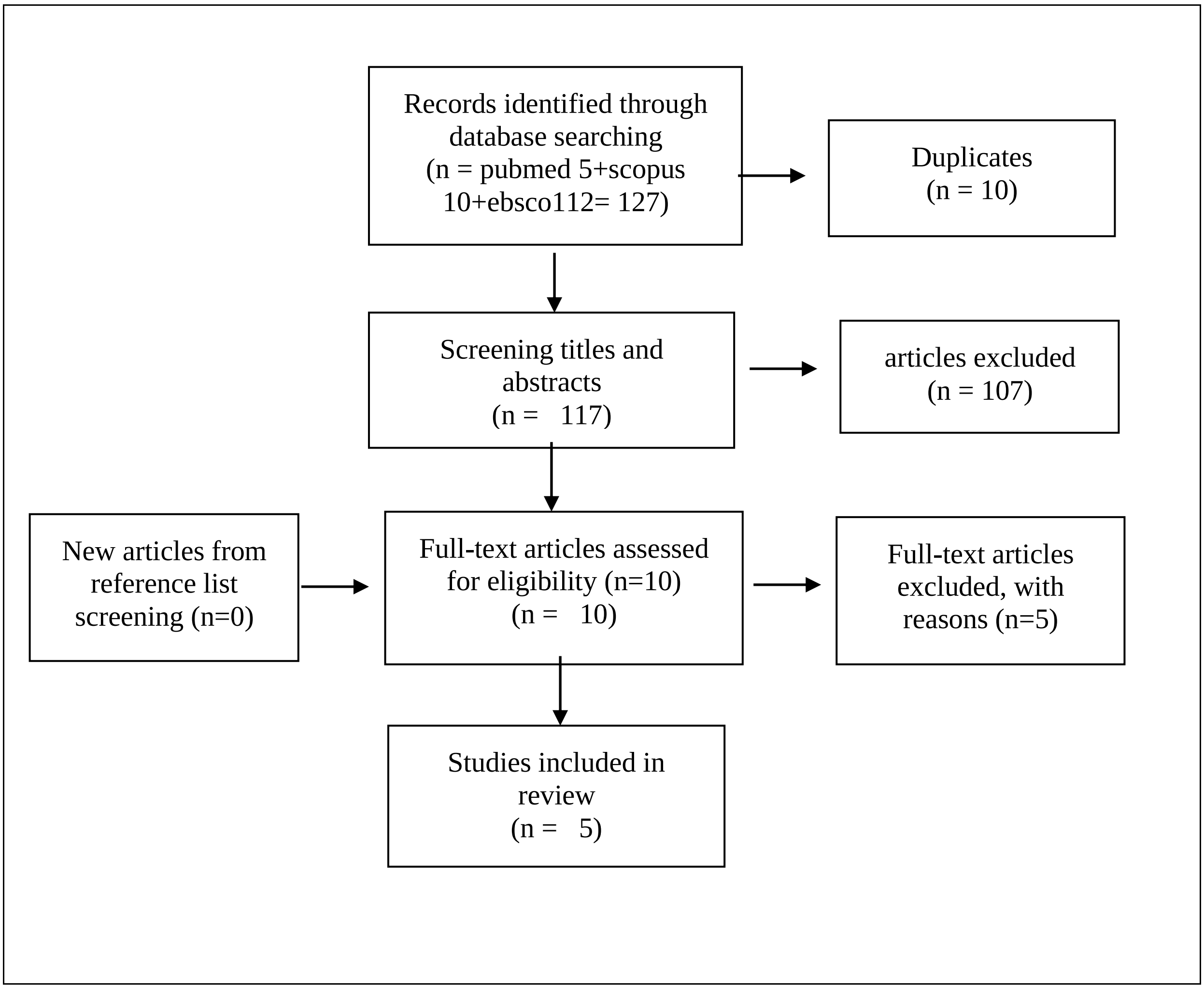

Figure 4.1 Flow chart for scoping review process

Reason for exclusion are shown in the table below.

Table 4.1 Reasons for exclusion of studies

Reasons for exclusion	Number of studies excluded
People with disabilities not involved in any sports	38
WB or wheelchair sports, not prevention of shoulder pain or injuries	61
Able bodied	8

Of the five articles, only two were experimental studies and the rest were review articles. In the two experimental studies (Wilroy & Hibberd, 2018; García-Gómez et al., 2019), home-based exercise programs were presented and implemented on WB players. Two of the review articles presented a rehabilitation protocol and a strength and conditioning program that may be applied in preventing shoulder pain among WB players (Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020). Curtis (1997) just presented recommendations of exercises that would be useful in preventing SP in wheelchair sports. The characteristics of the included studies and their recommended exercises are presented in the table below.

Table 4.2 Description of included studies

Title/ author(s)/ year/study design	Program type	Recommended exercise			
		Frequency	Intensity	Type	Time
Prevention and Treatment of Wheelchair Athletic In juries/ Kathleen A. Curtis/ 1997/ review article	N/A	Not indicated	Not indicated	Strengthening of posterior shoulder, including posterior deltoid, latissimus dorsi, rotator cuff, and middle and lower trapezius muscles	Not indicated
Evaluation of a Shoulder Injury Prevention Program In Wheelchair Basketball/ Jereme	Home-based	3 sets, 10 reps, week 1 and 4 3 sets, 15	Used 2 levels of resistance bands on the	Strengthening exercises including scapular retraction, ER,	6 weeks, 3 times/week

Title/ author(s)/ year/study	Program type	Recommended exercise			
Wilroy and Elizabeth Hibberd/ 2019/ Pretest and posttest/		reps, week 2 and 5 3 sets, 20 reps, week 3 and 6	participants' current ability, with first band used in the first 3 weeks then progressed to more difficult band next 3 weeks	and shoulder flexion for lower trapezius	
		3 reps, 20 seconds	N/A	IR stretch	
Effect of a Home-based Exercise Program on Shoulder Pain and Range of Motion in Elite Wheelchair Basketball Players: A Non-Randomized Controlled Trial/ García-Gómez et al/ 2019	Home-based	8 reps		Warm-up made up of 4 active movements of the GHJ	12 weeks,
		3 sets, 10 repetitions, with 45s rest between sets, and 10-15s rest between exercises	Variable resistance therapeutic band	5 strengthening exercises for serratus anterior, scapula retraction & depression, and shoulder rotation & adduction (rest between sets).	
		5 reps, 20 s hold, 15 s rest		5 stretching exercises for trapezius superior, medial and inferior portion, posterior shoulder, pectoral and biceps brachial muscles	
Shoulder Rehabilitation	N/A	60s hold, 3 reps		Acute phase 4 stretching	

Title/ author(s)/ year/study	Program type	Recommended exercise			
Protocol and Equipment Fit Recommendations for the Wheelchair Sport Athlete With Shoulder Pain/ Riley and Callahan/ 2019/ review article		10 reps, 3 sets, progressed to 20 reps, 3 sets, further progressed to 30 reps, 3 sets	Variable resistance using weights	exercises of the pectoralis minor, posterior shoulder, latissimus dorsi and levator scapulae 5 strengthening exercises of rotator cuff and scapula muscles	
		10 reps, 3 sets, progressed to 20 reps, 3 sets, further progressed to 30 reps, 3 sets	Variable resistance using weights	Maintenance phase 9 strengthening exercises of the rotator cuff, scapula muscles and other shoulder muscles like biceps brachii and latissimus dorsi	
		10 reps, 3 sets	Variable resistance	Performance phase All stretches from acute phase 5 strengthening exercises of the scapula muscles and other shoulder muscles	

Title/ author(s)/ year/study	Program type	Recommended exercise			
A Shoulder Strength Program for Wheelchair Basketball Players/ Lee et al/ 2020/ review article	N/A	Variable for strength, hypertrophy and endurance	Not specific, depending on goal	Upper body stretches including shoulder, chest and neck stretches Strengthening exercises of the chest, back & abs, and shoulders & arms	Not indicated

***Abbreviations: N/A – not applicable, reps – repetitions, IR – internal rotation, ER – external rotation, 10s – 10 seconds, GHJ – Glenohumeral joint, abs – abdominals.**

4.2.2 Study outcomes

All the studies support the inclusion of strengthening exercises of muscles of the shoulder complex, including the rotator cuff, and 80% of the studies include stretching for flexibility.

4.2.2.1 Warm-up

Three articles recommend the inclusion of warm-up for mobility and flexibility before proceeding to strengthening exercises (Curtis, 1997; García-Gómez et al., 2019; Lee, McKay & Gutierrez, 2020). Riley & Callahan (2019) began their acute and performance phases of their exercise protocol with stretching before strengthening exercises are done. They are not clear however whether the stretching could be considered as a form of warm-up or just part of the whole protocol. Only Wilroy & Hibberd (2018) do not mention warm-up in their study even though stretching was conducted after strengthening exercises.

4.2.2.2 Strengthening exercises

All the studies support the inclusion of strengthening exercises of muscles of the shoulder complex including the rotator cuff. However, the actual muscles included in the strengthening programmes varied among studies. While none of the studies specifically spoke to muscle endurance, two of the studies (Wilroy & Hibberd, 2018; Riley & Callahan, 2019) included dosage progressions of more than 15 reps. Lee, McKay & Gutierrez (2020) just provides dosages for strength, power, endurance and hypertrophy and leaves it to the discretion of the one prescribing.

4.2.2.3 Stretching or cool down

While all the studies recommend that stretching exercises should be done, some studies recommend it done before strengthening exercises (Curtis, 1997; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020) while others believe it should be done after strengthening exercises (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). The stretches included in the various studies varied, with pectoral muscles and posterior shoulder stretches common in all the studies except Curtis (1997).

4.2.3 Summary of scoping review findings

Five studies were included in the scoping review. All five of the studies acknowledge strengthening exercises of shoulder and scapular muscles of variable dosages to be beneficial in the prevention of shoulder pain among WB players or wheelchair sports athletes. Stretching of tight muscles and anterior shoulder structures have also been recommended. Finally, warm-up made of active movements have been recommended in few of the studies.

4.3 Delphi Results

4.3.1 Participant characteristics

The panel included five physiotherapists, with at least a bachelor's degree in physiotherapy, and one Biokinecitist with a Master of Science degree in sports science in the first round. The minimum years of experience related to basketball, wheelchair basketball or overhead sports was five years and a maximum of 20 years' experience. Below is a summary of participant characteristics.

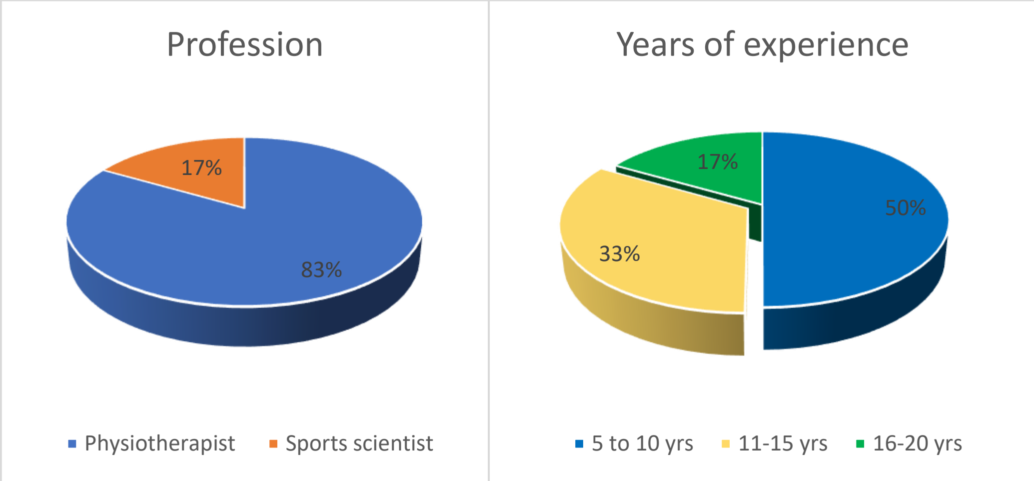

Figure 4.2 Pie charts showing participant characteristics

Five participants participated in the second round with one loss to follow up. Four participants confirmed to participate in this round. one was loss to follow-up while one had an emergency during the time of the meeting. See figure below.

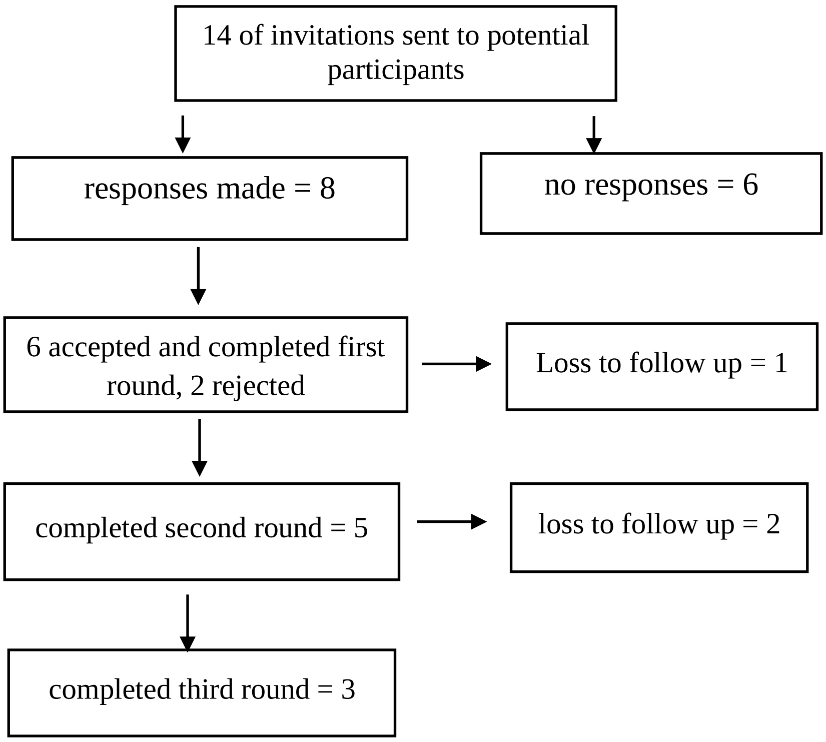

Figure 4.3 Participation of panel members in the 3 Delphi rounds

4.3.2 Quantitative summary

In the first round, nine out of 23 (39.1%) exercises of the prevention program reached consensus. The rest did not but had a median score of three and so were carried over to the second round. No exercise was excluded. No exercise reached consensus in the second round and in the third round 75% of the recommended modifications had a 100% agreement from panel members in the meeting. These modified exercises and all the exercises that reached consensus in the first round were all included in the final prevention program (*Appendix X*).

4.3.3 Warm-up

The warm-up section was made of seven exercises organised in two phases. The first phase was made up of four active range of motion exercises for mobility and flexibility of the shoulder and the second phase consisted of three functional exercises to encourage correct movement patterns.

4.3.3.1 Consensus

In the first and second rounds, all the exercises in the warm-up phase did not reach a consensus agreement of 80% as illustrated by figures 4.4 and 4.5 respectively. However, all of them had a median score of ≥3 (see figure 4.6) below.

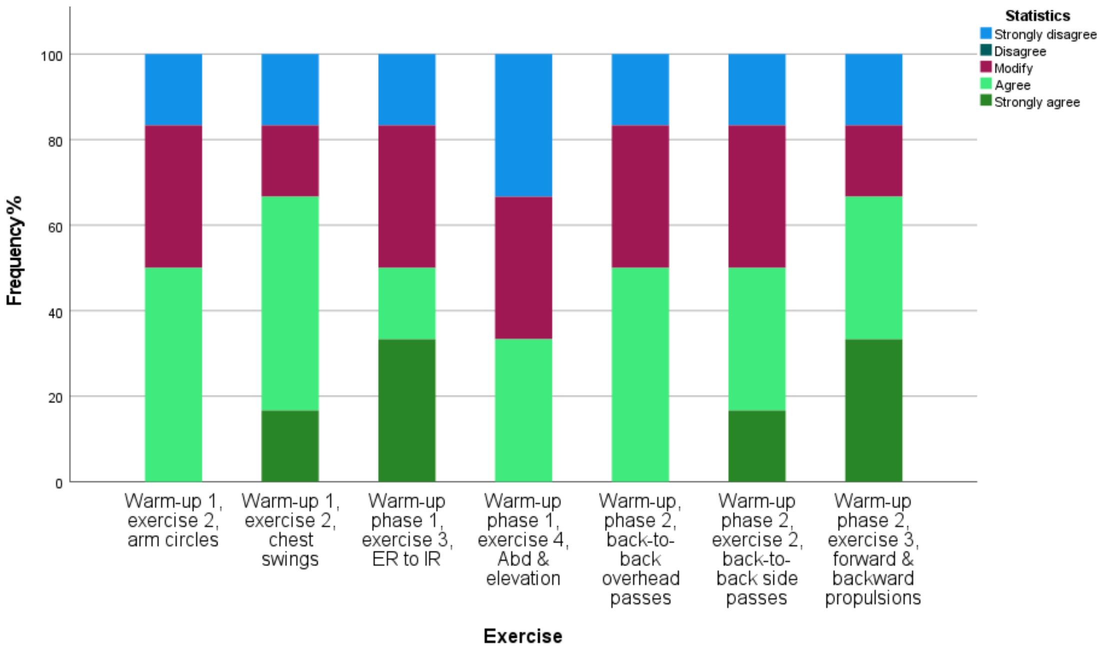

Figure 4.4 Frequency of responses for warm-up exercises in the first round

In figure 4.4, the percentage of agree and strongly agree responses are represented in different shades of green, with the highest percentage of just over 60% for chest swings and forward and backward propulsions.

In the second round, the frequency of modify responses increased and the percentage of agree responses generally reduced, with the highest agreement rate presented in green, being 40% (figure 4.5). The frequency in the second round was calculated with the drop out of one participant taken into account.

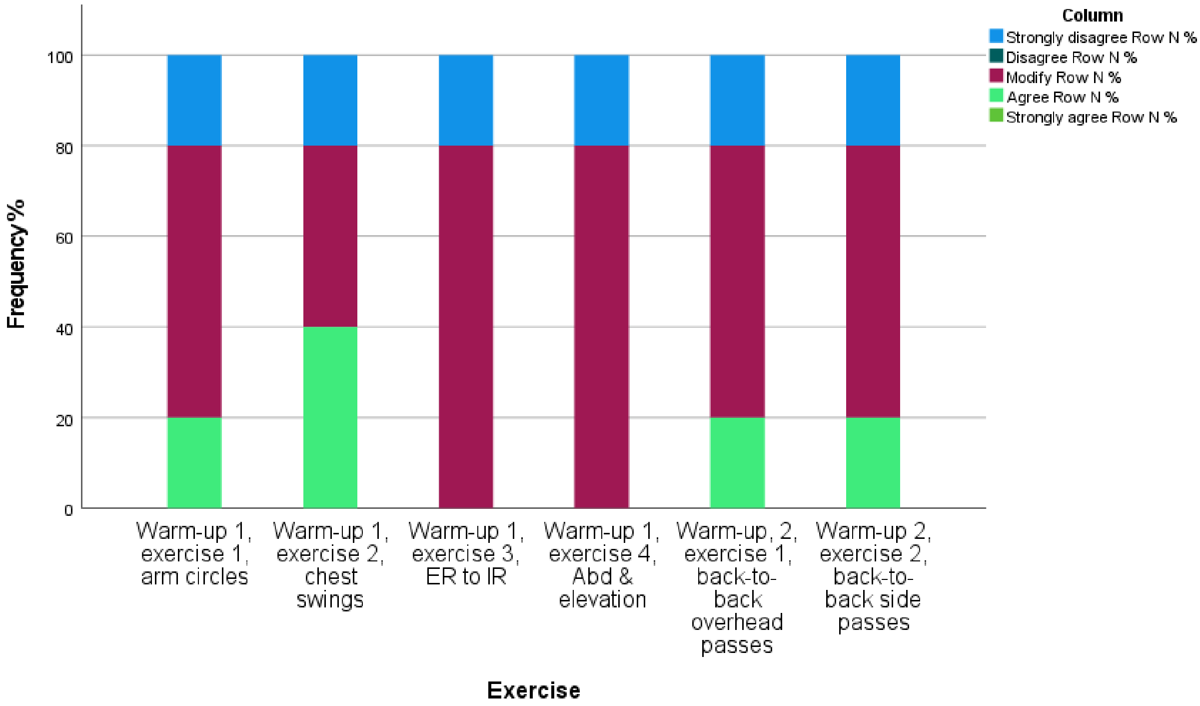

Figure 4.5 Frequency of responses in the second round

In the second round, participants selected different modifications recommended from the first round. Some participants however chose to maintain the exercises the way they were originally, even though the frequency for this had reduced compared to the first round. A descriptive summary of the selected modifications is provided in table 4.2 below.

Table 4.3 Descriptive summary of round 2 recommended modifications

Exercise	Recommended modifications	Descriptive summary
Arm circles	1- start with elbows flexed, remind players to set scapula down and slightly wide. Proceed to arm circles with extended elbows once warmed up 2- change abduction to PNF pattern	50% of the participants chose to modify with, 16.7% agreeing to modification 1 and, 33% agreeing to modification 2. ***One of these participants suggested to include both D1 and D2, flexion and extension patterns***, while ***the other one went with D2 extension pattern.***
Chest swings	1- the scapular needs to depress as well for lower fibers of trapezius	33% participants chose to modify and both of them agreed with the recommended modification
ER to IR	1- increase dose to 1 minute 2- include detailed description of how scapula will be stabilised	67% participants chose to modify with, 33% agreeing to modification 1 and, all 67% of the participants agreeing to modification 2
Abduction and elevation	1- focus on scapula position during exercise 2- shorten axis by flexing elbow 3- if elbow extension is maintained, add palms facing up to encourage external rotation beyond 90 degrees	67% of the participants chose to modify with, 16.67% agreeing to modification 1, emphasizing use of a picture to help players to visualise scapular position,

Exercise	Recommended modifications	Descriptive summary
		50% agreeing to modification 2 and, 33% agreeing to modification 3
Back-to-back overhead passes	1- the athletes should be placed facing each other 2- move exercise to new section, skills development section after cool-down 3- include trunk balance and scapular position	50% of the participants chose to modify with, all of them agreeing to modifications 1 & 2 and, 33% agreeing to modification 3
Back-to-back side passes	1- create and move exercise to skills development section 2- players should have wheelchairs side-by-side 3- include trunk balance and scapular position	50% of the participants chose to modify with, all of them agreeing to modifications 1 and 2 and, 33% agreeing to modification 3

Finally, consensus was affected by low participation in the third round, however there was 100% agreement for the participants in the meeting on some items. In the third round, for each exercise in the warm-up section, there was a modification or modifications that had 100% agreement among the participants present in the consensus meeting. Modification(s) or exercises that did not have 100% agreement were excluded in the final program.

4.3.4 Strengthening exercises

4.3.4.1 Consensus

Out of the nine strengthening exercises, three (33.3%) exercises including serratus anterior strength, chest press and lat pull up, reached a consensus agreement of ≥80% in the first round and so were excluded from the second round. The graph (figure 4.6) below provides a descriptive summary of how panel members rated the strengthening exercises. The percentage of participants that voted for each option (strongly disagree, disagree, modify, agree, and strongly agree) is shown, with agreement rate presented in different shades of green.

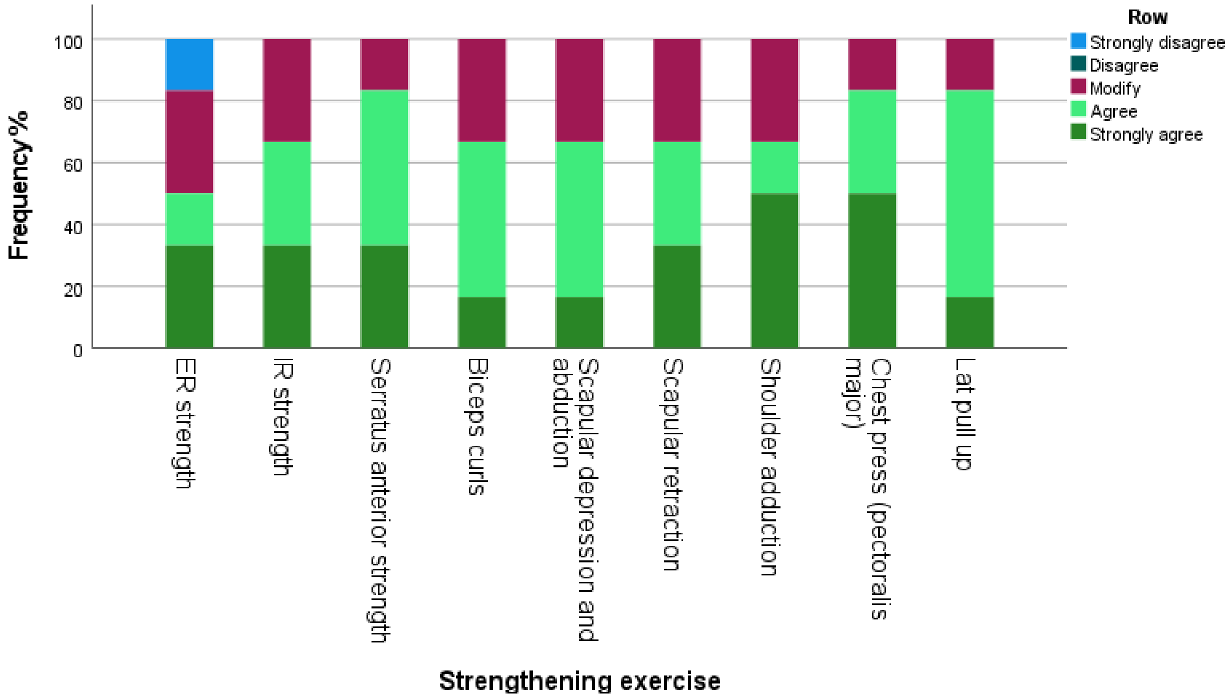

Figure 4.6 Frequency of agreement for each strengthening exercise in the first round

The trend continued in the section for strengthening exercises just like in the warm-up section. The frequency of modify responses slightly increased, with participants selecting different modifications recommended from the first round. Unlike the first round however, no participant disagreed with any of the strengthening exercises in the second round. Even with that however, none of the six strengthening exercises reached consensus in the second round. Below is a summary of the frequency of responses to the strengthening exercises in the second round.

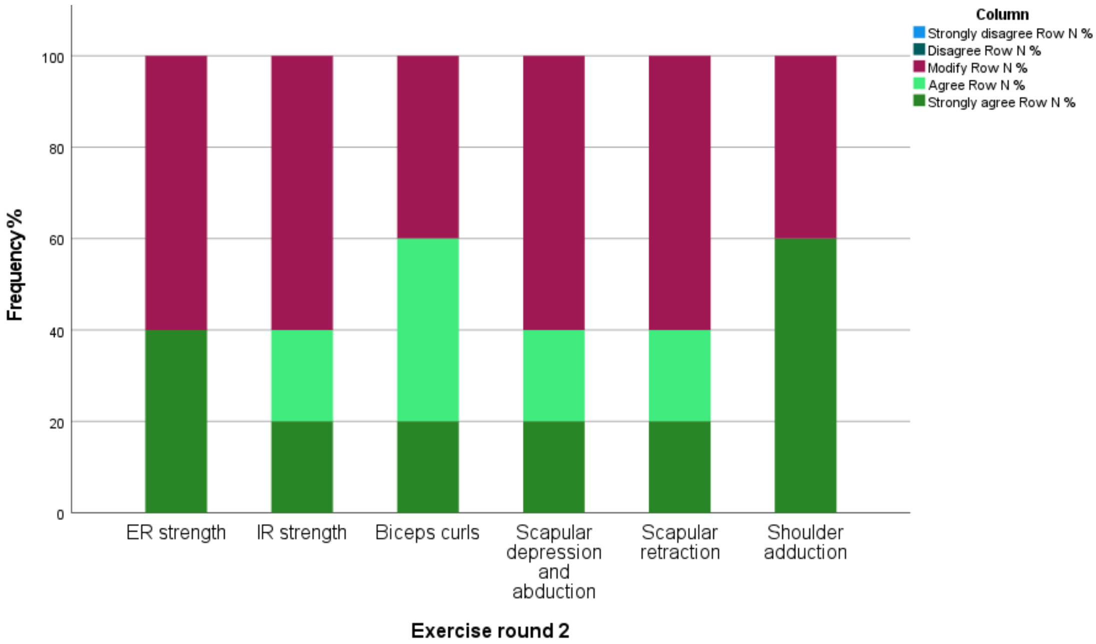

Figure 4.7 Frequency of responses for strengthening exercises in the second round

In the third round, consensus was affected by low participation, however 100% consensus for the participants in the meeting on some modified exercises which were added to the shoulder pain prevention program.

4.3.5 Scapular stabilisers activation

Two out of three (66.7%) exercises of activating scapular stabilisers, the serratus punch and lower trapezius activation, reached a consensus of ≥80% agreement clearly indicated in green the graph below. Only Y's t's & w's exercise did not reach consensus, with an agreement of 67%. The serratus punch and lower trapezius activation were excluded from the second round and were automatically part of the Shoulder pain Prevention Program in w/c basketball (SPP-WB). The chart below shows a summary of the number of panel members voted for each category (strongly disagree, disagree, modify, agree, and strongly agree) for each exercise.

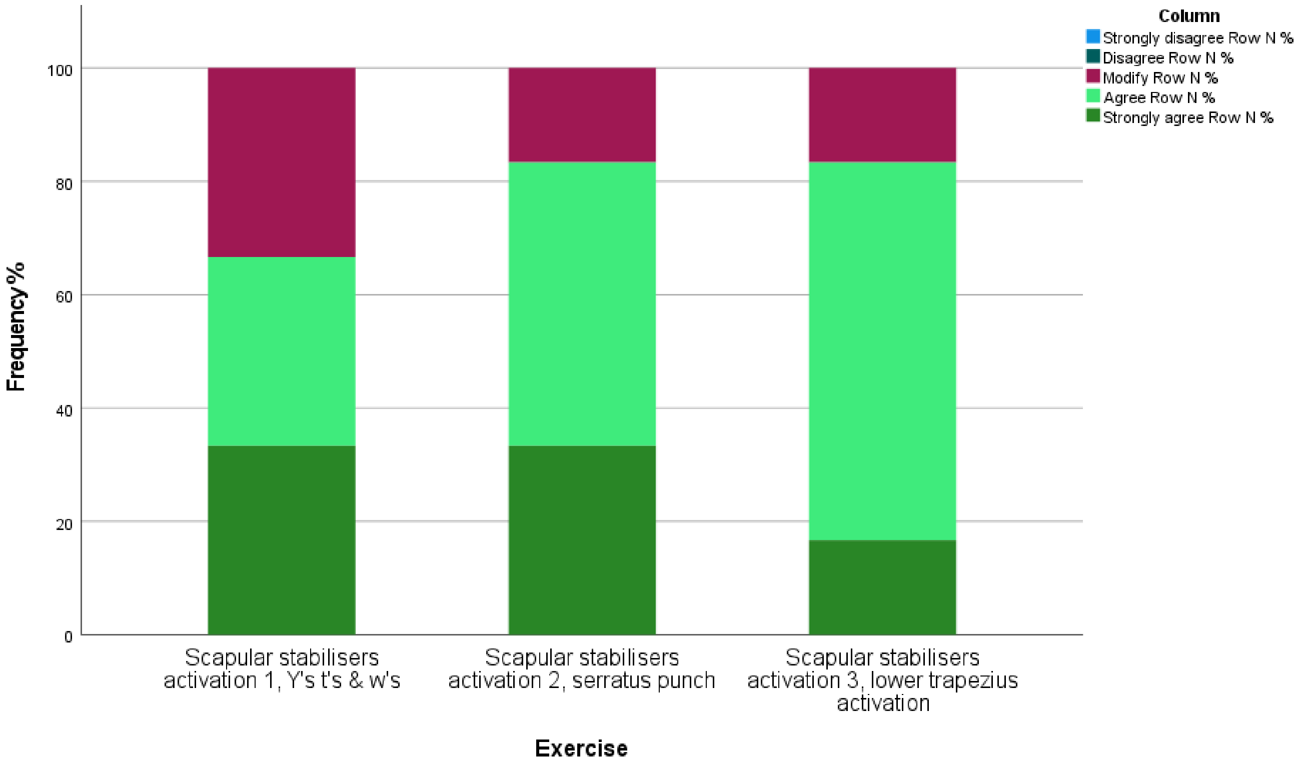

Figure 4.8 Frequency of responses for scapular stabiliser activation exercises

At least half of the participants agreed with Y's t's & w's exercise, with a median score of four. This exercise was therefore included in the second round of the Delphi, with its recommended modifications presented. There was also less variation in the responses indicated by an interquartile range of one.

In the second round, the y's, t's, w's still had an agreement rate of <80%. However, in the third round, it was accepted by all the participants in the final round as it was, with the note to take care of participants that may find it challenging to go into prone position and advise therapists or qualified user of program to adjust as appropriate in those instances.

4.3.6 Cool down

All four stretches in the cool down section reached a consensus of ≥80% agreement, with posterior capsule stretch having 100% agreement, in the first round. All four exercises were therefore excluded from the second round and were automatically included in the SPP-WB. There was also little variation, with only one participant opting to modify the other three exercises with interquartile ranges from 0.25 to 0.45. Below is a chart presenting the frequency of agreement. The group's median score is presented in figure 4.9 below.

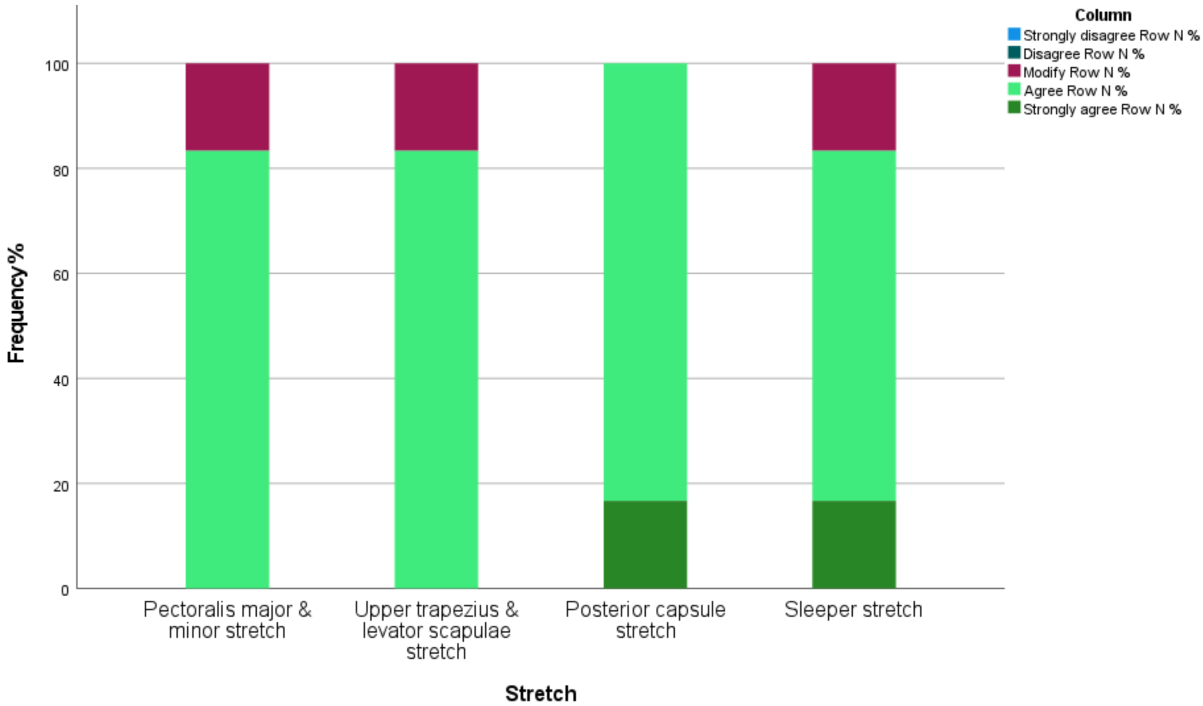

Figure 4.9 All cool-down exercises having >80% agreement

4.4 Qualitative results

According to the data analysis, there was a high tendency of answers regarding altering the procedure of certain exercises in all the sections of the program, including the two recommended modifications in the cool down section. There were also responses regarding altering the dosage and the type of exercises. Responses covering other aspects for example causing injury were also there, though few but very significant.

4.4.1 Altering the procedure of an exercise

Related to altering the procedure, participants talked about preventing injury, focusing on vital components during the exercise for example scapular stabilisation and mobility, position exercise is conducted in, range of movement throughout exercise, reducing the kinetic chain by performing an exercise with arm flexed and changing positioning of wheelchairs for exercise done in pairs, especially during the warm-up phase (both 1 and 2). For example, with regards to arm circles, Participant 12 commented that “the long axis of the extended arm may add strain to some with existing injury or pathology. As an initial warm-up I’d suggest doing this with elbows flexed and only done with elbow extension once warmed up.” In the same regard, participant 09 commented that “start arm circles with elbows flexed and remind the players to set their scapula down and wide for both exercises. I would either change abduction to a PNF pattern or add shoulder flexion as well." Meanwhile participant 08 on commenting about back-to-back overhead passes said that "this appears to demand high skill, precision and body awareness in space, therefore may not be suitable for warm-up. This can do well in skill development section- which can be another section before cool-down. Alternatively the athletes can be placed facing each other.”

For serratus anterior strength in order to achieve optimal results, participant 09 suggested that the scapula be abducted and that a wall push upon press with a plus would achieve better results.

In the scapular stabilisers section with regards to altering the procedure, participant 12 suggested that “Again, just consider whether prone is the most appropriate position to get into. You could possibly adapt to do in forward-leaning supported seated.”

4.4.2 Altering the dosage of an exercise

There were no suggestions with regards to altering the dosage for the warm-up section. However, there was a suggestion to alter the dosage by one participant or more for all the strengthening exercises. With regards to all the parameters of the FITT principle of exercise prescription, participant 09 suggested that “These players need strength endurance and not pure power. I would increase the reps and reduce the weight for 6 weeks and then add 6 and 1 rep max exercises after 6 weeks due to the muscle breakdown that will occur and increase with 1 rep max per week.” Participant 08 suggested that “I would prefer if start dosage was set at 8 reps,” in addressing altering the dosage for IR strength.

4.4.3 Changing section of exercise

In the warm-up section, two exercises were suggested to change section from warm-up to a new section, skill development section, after cool-down. Participant 08 commented that “this appears to demand high skill, precision and body awareness in space, therefore may not be suitable for warm-up. This can do well in skill development section- which can be another section before cool-down. Alternatively the athletes can be placed facing each other.”

In the strengthening exercise section, two exercises involving scapula movement were suggested to be moved to the warm-up section. “I think scapular mobilisation is a very important part of shoulder care and that this exercise should perhaps be moved to the warm-up section to ensure scapulae are mobile and activated before shoulder warm-ups.” Participant 12.

4.5 The shoulder pain prevention programme

The final shoulder pain prevention programme, attached as *appendix XI* has been made up of the nine exercises that reached consensus in the first round and the modified exercises that had 100% agreement in the final round.

Chapter 5 Discussion

The purpose of this research was to develop an exercise program that could be used to prevent shoulder pain in WB. To do this, a scoping review was conducted to identify exercises, if any, that have been recommended for the prevention of shoulder pain. Then, expert opinion was sought on the identified exercises to create a new program that was holistic.

There is limited research in shoulder pain prevention among wheelchair basketball players as evidenced by only the five studies identified in the scoping review. Moreover, only two of these studies were experimental studies. This is in agreement with all the studies included in the scoping review. Heyward et al (2017) also pointed out limitations in research in this area. In addition to this, the two experimental studies included in the review (Wilroy & Hibberd, 2018; García-Gómez et al., 2019), adapted their exercise programs from swimmers and manual wheelchair users respectively. This study adapted the exercise program from studies that were for wheelchair athletes or WB basketball.

A systematic review done on studies for wheelchair sports (Heyward et al., 2017) reported no use of valid measurement tools in their included studies except for two studies. In this study, the two experimental studies included instruments that had been validated.

All the studies included in the scoping review focused on strengthening of the shoulder girdle muscles including the rotator cuff muscles and scapular stabilisers. The rationale for strengthening exercises according to these studies was to deal with the muscle imbalances prevalent at the shoulder. Rotator cuff muscles are active in both the push and recovery phases of wheelchair propulsion and during overhead activities (Mulroy et al., 1996; Vanlandewijck, Theisen & Daly, 2001). In addition to this, the repetitive nature of these activities during WB makes the rotator cuff prone to fatigue and overuse. Therefore, all the studies support strengthening of some or all rotator cuff muscles. Strengthening of posterior shoulder muscles, including trapezius, rhomboids, posterior deltoid, latissimus dorsi and rotator cuff has been encouraged as manual wheelchair users, including WB players, are reported to have relatively weaker posterior muscles compared to anterior muscles (Curtis & Black, 1999; Wilroy & Hibberd, 2018; García-Gómez et al., 2019).

Inclusion of warm-up in the included studies was variable. García-Gómez et al (2019) structured their exercise program by beginning with active movements of the shoulder as a warm-up. The warm-up was then followed by strengthening and finally stretching exercises. This structure was reported to be a valid structure of a home-based exercise program to maintain shoulder condition, in order to prevent development of shoulder pain among WB players (García-Gómez et al., 2017). Curtis (1997) and Lee, McKay & Gutierrez (2020) also recommended beginning warm-up before strengthening exercises. According to Brukner & Khan (2017), warm-up prepares the body physically and mentally for exercise and so it is an essential component in injury prevention. In this regard, warm-up increases perfusion of blood to muscles from 15% at rest to about 70% (Hughes, 2002). This increased blood flow washes away waste substances and brings more oxygen for aerobic respiration, preventing lactic acid build up and in essence fatigue (Hughes, 2002).

Even though all the studies recommended inclusion of stretching exercises of shoulder muscles, evidence on the effects of stretching is still inconclusive (Hughes, 2002; Brukner & Khan, 2017). According to Hughes (2002), some studies even report an increased risk of injury due to a reduction of power and physical performance brought about by stretching before exercising. The majority of included studies (n=3) do not seem to agree with this concept as they recommend conducting stretches before strengthening exercises (Curtis & Black, 1999; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020). The two experimental studies however, did stretching after strengthening exercises and they found that it improved the range of motion of the shoulder (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). In agreement with this, Brukner & Khan (2017) backed appropriate stretching, with caution not to overstretch and to warm-up before, to improve flexibility and range and to decrease risk of injuries. The stretches included in the various studies varied, with pectoral muscles and posterior shoulder stretches common in all the studies except Curtis (1997).

Members of the expert panel comprised of five physiotherapists and one sports scientist, with a minimum of five years of experience in WB or wheelchair sports. This was consistent with another study in which the majority of their sample were physiotherapists as well (García-Gómez et al., 2017). Their expert panel consisted of nine members in total, with four physiotherapists, three coaches, a rehabilitation physician and a sports physician. The researchers’ background in physiotherapy and the use of convenience sampling method in their expert opinion studies may have contributed to this. Multiple studies have reported that WB players with SP mostly sought treatment from physiotherapists (Lepera, 2010; Mateus, 2015; Christiana, 2019). Physiotherapists managing and interacting with a lot of WB players with SP could be another reason.

In their study, García-Gómez (2017) reported that experts were providing specific responses with regards to the content, structure and sequence of the program. Similarly in this study, panel members were very specific in their responses. In this regard, panel members recommended alterations in procedures, dosages, type or even section of exercises for optimal function of the program. Recommendations were even made on perhaps varying the exercises in different weeks to avoid boredom or splitting the exercises so that they are conducted in different weeks.

During the third round of the Delphi, consensus was affected by dropouts. However, there was 100% agreement for some of the modifications and these were added to the programme.

To prepare the body for exercise, the proposed SPP begins with a warm-up consisting of active movements of the shoulder and scapula. Though some studies identified in the scoping review included warm-up in their programmes (Curtis & Black, 1999; García-Gómez et al., 2019; Lee, McKay & Gutierrez, 2020), the inclusion of scapula mobility in the warm-up is unique to this study. With scapula positioning and mobility vital in the development of SP among WB players, it was extremely necessary to focus on it from the beginning of the programme.

The proposed programme also includes strengthening exercises of shoulder adductors including latissimus dorsi and pectoralis major, scapulothoracic muscles, rhomboids, trapezius and serratus anterior, and rotator cuff muscles. Previous studies have recommended strengthening of these muscles due to muscle imbalances and overuse observed in wheelchair athletes (Burnham et al., 1993; García-Gómez et al., 2017; Heyward et al., 2017; Wilroy & Hibberd, 2018). In comparing the strength of shoulder girdle muscles between WB players and able-bodied athletes, Burnham et al. (1993) found that WB players generally had stronger muscles. The rationale is that WB players use their upper limbs for function as well and considering most of the upper limb force production comes from the shoulder during hand rim wheelchair propulsion (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001), the shoulder muscles adapt. However, relative weakness of shoulder adductors to abductors and posterior muscles (scapulothoracic muscles) to anterior muscles has been reported in this group (Burnham et al., 1993; Curtis & Black, 1999; Aytar et al., 2015; Heyward et al., 2017; García-Gómez et al., 2019). Strengthening of the biceps brachii has been included in the programme due to its role in dynamic stabilisation of the shoulder.

Furthermore, particular emphasis has been placed on endurance exercises for the shoulder girdle muscles before progressing to the strengthening exercises. WB players are involved in repetitive activity during the sport and ADLs including wheelchair propulsion and shooting. These repetitive activities are known to lead to muscle fatigue leading to overuse which has been highly associated with the shoulder pain among WB players (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001; Heyward et al., 2017). Therefore, it was deemed vital to not only focus on pure strength but strength endurance. For the rotator cuff, muscle endurance exercises could prove to be a game changer as they are prone to fatigue because of their constant activity during the push and recovery phases of the wheelchair propulsion cycle (Vanlandewijck, Theisen & Daly, 2001; Boninger et al., 2002) and during shooting and passing to provide dynamic stabilisation of the GHJ (Veeger & van der Helm, 2007; Akbar et al., 2015; Heyward et al., 2017).Moreover, even though three of the studies (Wilroy & Hibberd, 2018; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020) included in the scoping review did not specifically mention muscle endurance, their progression dosages for strength related more to endurance, with repetitions of >20 suggested.

Apart from fatigue of the rotator cuff muscles, WB players are also known to have altered scapula kinematics with the scapulae anteriorly tilted and internally rotated, leading to tightness of anterior structures of the shoulder and weakness of scapular stabilisers (Aytar et al., 2015; García-Gómez et al., 2019). In order to correct this, the SPP includes strengthening, mobility and activation exercises of scapula stabilisers. In keeping with this, Wilroy & Hibberd (2018) and García-Gómez et al (2019) included scapular retraction strength and strengthening exercises of other scapular stabilisers as part of their programmes. Burnham et al (1993) also thought it would be helpful to encourage scapular retraction and avoid the protracted scapula position. Taking this a step further, emphasis was also placed on mobility and appropriate positioning of the scapula during the strengthening exercises because of altered scapulohumeral rhythm that tends to happen (Aytar et al., 2015). It was therefore recommended that WB players should be given visual and verbal cues on mobility and positioning of the scapula during exercises that involve elevation and abduction of the shoulder. This study also includes scapular mobility during warm-up as scapular mobility and stability are vital in WB.

Interestingly, a new skills development section, was added to the program during the Delphi rounds. This section consists of sport specific exercises that involve hand rim wheelchair propulsion and shooting of a basketball. The inclusion of sport specific exercises in this program may be vital in preventing SP during the specific motions, including hand rim wheelchair propulsion and shooting, that have been associated with SP. Particular effort should be placed on ensuring that the correct technique is done during the exercises and sports. According to Silva et al (2018), a good exercise program consists of both specific and general exercises. Even though this was specific to warm-up, it can be applied in our study as well. The stroke pattern or propulsion style has not been specified in this program but there is some evidence that supports the use of the semi-circular or under the rim stroke pattern as it tends to improve upper extremity function by having longer push angles and reducing initial braking moment, stroke frequency and power loss in manual wheelchair users (Boninger et al., 2002; Koontz et al., 2009; Kwarciak et al., 2009). Improved function of the upper limb may in turn result in conservation of upper limb health (Kwarciak et al., 2009). However, this has not been directly associated with prevention of SP in manual wheelchair users, much less WB players. For WB players, considerations should also be made on the propulsion style in relation to prevention of SP and optimisation of performance or at the very least not negatively impacting performance. All in all, this still needs to be explored further.

Finally, stretching exercises were included in the cool down phase of the program. All the four stretches reached consensus agreement in the first round without any modifications. These stretches were targeting anterior chest muscles (pectoralis major and minor) which are reported to be tight due to poor posture (Vanlandewijck, Theisen & Daly, 2001; Yildirim, Comert & Ozengin, 2010; Aytar et al., 2015)and posterior capsule, upper trapezius, levator scapulae and internal rotators, which get tight when manual wheelchair users have limited IR ROM (García-Gómez et al., 2019). In agreement with this, all studies included in the scoping review recommended the inclusion of stretching in the prevention of shoulder pain among WB players and wheelchair athletes in general. The stretching exercises in the SPP have been included in the final section of the program, after all the other exercises of the program because evidence of stretching before exercising is still inconclusive. Moreover, García-Gómez et al (2017) found the structure of their SPP that placed stretching after strengthening exercises to be valid. In addition to this, Wilroy & Hibberd (2018) and García-Gómez et al (2019) reported improvements in flexibility as a result of their stretching exercises, which were done after strengthening exercises.

Chapter 6 Conclusion and recommendations

6.1 Conclusion

Shoulder pain is a problem among WB players. This study has provided a program that may be utilized to prevent SP among WB players. Apart from aspects like strength and stretching, this study has included other exercises including muscle endurance, activation of scapular stabilisers and skill specific exercises that may prove necessary in the prevention of shoulder pain among WB players.

6.2 Clinical/practical recommendations

It is recommended that the WB player be assessed by a Physiotherapist (PT) or recognised professional for example a sports scientist to determine the appropriate dosage for them before implementing this program. Some exercises can be adjusted to the ability of the player. Moreover, when considering implementing this program, physiotherapists or coaches should consider strength endurance vs pure power and apply to the way their athletes are presenting.

In addition to the above recommendations, it is necessary for implementers to be aware of scapular position and mobility during exercises for effective implementation. Postural recommendations by Gómez (2018) may be considered when implementing this program as postural challenges are massive among WB players.

6.3 Recommendation for future research

Further research should be conducted on prevention of shoulder pain among WB players generally and with a focus on the classification as a confounding variable. Future research should consider closing the gap in causes of shoulder pain among WB players through longitudinal studies. The effect of implementing this program on incidence of shoulder pain among WB players could also be explored.

6.4 Strengths and limitations

This study has a number of strengths. Firstly, the methodology of the study consisting of a scoping review and a Delphi was appropriate for this study because of the limited information on prevention shoulder pain among WB players. The Delphi with its feedback process allowed for comprehensive input from each of the expert panel member for which other opinion studies lack due to panel members not being aware of the other members' responses making it the best way to develop this programme. This study has explored options for prevention of shoulder pain among WB players in South Africa which to my knowledge has not been explored. Finally, the prevention program maybe be explored further and implemented.

This study, however, also has its limitations. Firstly, consensus was affected by low participation in the subsequent rounds of the Delphi. An expert opinion study is a low evidence study but was the design for the research question. The lack of use of a validated instrument is another limitation of the study. Finally, the fact that experts were not given the opportunity to create their own exercises is also a limitation in this study.

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Appendices

Appendix I Search strategy

Database: Medline via PubMed
Date of search: 23 March 2021
Restriction: English Language
Terms were searched for in “Textword and MeSH”, where possible
Search 3: ("shoulder pain"[Text Word] OR "shoulder injury"[Text Word] OR "shoulder joint/injuries"[MeSH Major Topic]) AND "wheelchair basketball"[Text Word] AND ("prevention"[Text Word] OR "intervention"[Text Word] OR "program*"[Text Word])

Retrieved: 4 articles

Database: EBSCOhost (MEDLINE; CINAHL Complete; MasterFILE Premier; MEDLINE Complete; OpenDissertations; SPORTDiscus with Full Text)

Date of search: 23 March 2021

Restrictions: English Language, reference available, full text available

Terms were searched for in “AB Abstract”

Search 3: S1 AB shoulder pain OR AB shoulder injury
S2 AB wheelchair basketball OR AB wheelchair sports OR AB overhead sport
S3 AB intervention OR AB prevention OR AB treatment OR AB program*
S4 (S1 AND S2 AND S3)
Retrieved: 144 articles
Restrictions: None

Database: Scopus

Date of search: 23 March 2021

Retrieved: 10

Restrictions: English Language

Terms were searched for in “Title, Abstract and Keywords”

Search: (TITLE-ABS-KEY (shoulder AND pain) OR TITLE-ABS-KEY (shoulder AND injury) AND TITLE-ABS-KEY (wheelchair AND basketball) AND TITLE-ABS-KEY (program*) OR TITLE-ABS-KEY (treatment) OR TITLE-ABS-KEY (prevention) OR TITLE-ABS-KEY (intervention))

Appendix II Information sheet

Information Sheet: Expert Panel

Faculty of Health Sciences · Private Bag 3, Wits, 2050, South Africa

Tel: +267 72 643 400 E-mail: 2359654@students.wits.ac.za

Study title: Development of a shoulder pain prevention programme for wheelchair basketball players in Johannesburg, South Africa.

Dear Panel member

I, Tawina Msadala, am researching the development of a shoulder pain prevention programme through an expert-based consensus in a modified Delphi study. A Delphi study is a multi-staged study that aims to obtain consensus from a group of experts on specific topics. The aim of this study is to develop a shoulder pain prevention programme for wheelchair basketball players in Johannesburg, South Africa. Shoulder pain is very common in wheelchair basketball and is said to occur in over 50% of wheelchair basketball players at some point in their career. This research will identify areas that lead to shoulder pain and exercises that could be done to prevent it.

I would be very grateful if you would be willing to participate in this research project which is scheduled to commence in March 2022 and finish in April 2022

Who is eligible to participate in the study?

The nature of this study requires expertise and experience in wheelchair basketball, basketball or overhead sports. Males and females from South Africa who are currently involved in/with wheelchair basketball or basketball or overhead sports for more than two years. They should be qualified Physiotherapists/Sports Physiotherapists, Biokenecitists and or Sports Scientists who are registered with HPCSA and are interested in developing a shoulder pain prevention programme for wheelchair basketball players.

What is involved in the study?

This study will involve a scoping literature review from which the researcher will compile exercises that are being considered to be included in the shoulder pain prevention programme. After the scoping review, the researcher will put together a questionnaire with the specific content of the exercise programme for wheelchair basketball players in Johannesburg. Delphi participants will then be sent this questionnaire for their inputs as round one. This questionnaire should take you about fifteen to thirty minutes to complete via Redcap (online system). Participants will be given 10 days from 07 March 2022, to complete the questionnaire.

Then feedback from the first round will be compiled into a second questionnaire which will be sent again to participants to complete after ten days from the date of completion of the first questionnaire. As with the first round, panel members will be given ten days to complete the questionnaire via RedCap.

The third round will consist of an expert panel meeting conducted online through Zoom in the first week of April 2022. All exercises with a median score of three that did not reach consensus, which has been set at 80%, will be discussed. Panel members will be allowed to make iterations based on the discussion and will be required to email their iterations to the researcher in five days. During the meeting, panel members will be referred to using assigned codes that will be emailed to you before the meeting.

Your anonymity will be maintained during the feedback process. Two reminders will be sent during each round of the Delphi process, the first after five days and the second three days later. The first reminder will be in form of an email and the second reminder in form of a text message or phone call.

The final compiled shoulder pain prevention programme will be emailed to you.

Anticipated number of rounds

This study involves a preliminary round and three subsequent rounds. Participants will be involved in the three rounds where the first two will each take approximately thirty minutes to complete. The final round will take two hours.

Time commitment

The Delphi however being a multi-stage process, will run over a period of five weeks.

Are there any risks in taking part in this study?

You will not be exposed to any risk by participating in this study.

What are the benefits of taking part in this study?

The final shoulder pain prevention programme for wheelchair basketball players will be given to you. There will be no monetary award for participating in this study.

Will information be handled as confidential?

Efforts will be made to keep the information confidential. Personal information will only be on the consent form and demographic sheet to ascertain your eligibility in the study and not the questionnaire and will not be disclosed unless required by the law. To ensure confidentiality, each panel member will be assigned a study number that will be kept by the researcher only. All information will be used only for the intended purpose of this study.

For further information, you are welcome to contact me on +267 72 643 400 or send an email to 2359654@students.wits.ac.za

For more information on, or the reporting of ethical concerns, you may contact the chair of the Human Research Ethics Committee of the University of the Witwatersrand:

Dr Clement Penny; Tel: 011-717-2301 Email: Clement.Penny@wits.ac.za.

Regards,

Tawina Msadala

MSc Physiotherapy in Sports

Appendix III First Round Questionnaire

Exercise Program

Several factors have been associated with shoulder pain among wheelchair basketball players including muscle imbalances and weakness, abnormal positioning of the scapula and posture, and range of motion and flexibility deficits. It has been reported that wheelchair basketball players have significant weakness of shoulder adductors compared to abductors, predisposing them to impingement. These adductors, latissimus dorsi, teres major and lower fibers of pectoralis major, provide a balancing force to the action of shoulder adbuctors. In addition to imbalance in strength, wheelchair basketball players have been reported to have weakness of external rotators and scapular retractors.

Abnormal positioning and movement of the scapula among wheelchair basketball players, with the scapula anteriorly tilted and protracted, has been associated with weakness of scapula stabilisers most notably the rhomboid muscles and lower fibers of trapezius. This protracted position of the scapula also results in weakness of the serratus anterior, tightness of pectoralis minor, and a reduced internal rotation range of motion of the shoulder.

The goal of this research is to create a comprehensive program for prevention of shoulder pain among wheelchair basketball players in South Africa. As such a scoping review was conducted which informed the exercises in this questionnaire.

Please complete the survey by rating the exercises.

Thank you!

WARM-UP

Phase 1

Goal(s): For mobility and flexibility

Exercise Procedure Equipment Dosage Arm circles Sitted on a wheelchair, abduct arms to 90 degrees with elbows extended, then circumduct arms repeatedly None 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	______________________________
Exercise Procedure Equipment Dosage (FITT) Chest swings Starting with both arms adducted with elbows flexed above 90 degrees while sitted on a wheelchair, simultaneously abduct arms and retract scapula at end range None to 1kg dumbbells after 3 weeks 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended recommendation (if any)	______________________________
Exercise Procedure Euipment Dosage External rotation to internal rotation Sitted on a wheelchair with shoulder in neutral, stabilised to the body by a resistance band, then move the arm into internal rotation and then take it to external rotation Theraband/resistance band 30 seconds	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended recommendation (if any)

Exercise Procedure Equipment Dosage Abduction and elevation Sitted on a wheelchair, with elbows extended, raise arms into abduction and elevation None 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended recommendation (if any)

Warm-up

Phase 2

Goal(s): To encourage correct movement patterns

Exercise Procedure Equipment Dosage Back-to-back overhead passes With a partner and wheelchairs placed back-to-back, a basketball is passed overhead between the players with elbows extended Basketball 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended recommendation (if any)

Exercise Procedure Equipment Dosage Back-to-back side passes With a partner and wheelchairs placed back-to-back, a basketball is passed side by side between the players with elbows extended Basketball 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended recommendation (if any)

Exercise Procedure Equipment Dosage and progression Forward and backward wheelchair propulsions Sitting on a wheelchair, propel wheelchair forward as you can for 50m and then propel backwards 50m None 1 minute	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended recommendation (if any)

STRENGTHENING EXERCISES

Goal(s):

Exercise Procedure Equipment Dosage and Progression External rotation strength With shoulder in neutral pressed against the body and elbow bent to 90 degrees, take hand and forearm out and then back to neutral. While sitted on a wheelchair Dumbbell and foam or towel 60% of 1 rep max, 6 reps, 3 sets, 30 seconds rest between sets for first 3 weeks. 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest after 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest after 3 weeks	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	______________________
Exercise Procedure Equipment Dosage and Progression Internal rotation strength With shoulder in neutral pressed against body and elbow bent to 90 degrees while carrying a dumbbell, take forearm and hand close to abdomen and then back to neutral Dumbbell and foam or towel 60% 1 rep max progressed to 80% 1 rep max after 3 weeks, 6 reps, 3 sets, 30 seconds rest. Further progressed to 80% 1 rep max, 10 reps, 3 sets, 30 seconds rest.	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	

Exercise Procedure Equipment Dosage and Progression Serratus anterior strength Sitted with shoulder in neutral and elbow bent 90 degrees, straighten elbow and lift shoulder up. Dumbbells 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for 3 weeks. 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest after 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest after 3 weeks	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________
Exercise Procedure Equipment Dosage Biceps curls Shoulders in neutral and elbows 90 degrees, lift forearm up. Dumbbells 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for weeks. 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest after 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest after 3 weeks	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________

Exercise Procedure Equipment Dosage and Progression Scapular depression and abduction Grab resistive band in front of wheelchair with elbow straight and depress and retract scapula Resistive band Moderate resistance, 6 reps, 3 sets, 30 seconds rest between sets for 4 weeks. Maximum resistance, 3 sets, 10 reps, 30 seconds rest between sets next 5 weeks.	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________

Exercise Procedure Equipment Dosage and Progression Scapular retraction Shoulders neutral with elbows flexed 90 degrees, retract scapula while moving forearms outwards Dumbbells 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for 3 weeks. Progressed to 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest next 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest next 3 weeks	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________
Exercise Procedure Equipment Dosage and Progression Shoulder adduction Shoulders abducted 90 degrees, elbows extended, pull resistance band close to your body and return to starting position Resistive band Moderate rseistance, 6 reps, 3 sets, 30 seconds for 4 weeks. maximum resistance, 10 reps, 3 sets, 30 seconds rest for next 5 weeks.	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________
Exercise Procedure Equipment Dosage Chest press (pectoralis major) Supine on a bench, Shoulders abducted to about 90 degrees, elbows 90 degrees. Straighten elbows and shoulders and then return to starting position Dumbbells 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for 3 weeks. Progressed to 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest next 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest after 3 weeks	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	__________________________________

Exercise Procedure Equipment Dosage Lat pull up Prone on a bench, Shoulders abducted to about 90 degrees and elbows flexed 90 degrees, pull up dumbbells and back Dumbbells 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	

SCAPULAR STABILISERS ACTIVATION

Exercise Procedure Equipment Dosage Y's, t's w's In prone, abduct arms to about 160 degrees, then keep moving them up and down (Y's) t's conducted with arms at 90 degrees abduction w's with arms at about 140 degrees abduction None Low to moderate intensity, 15 reps, 1 set each	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	______________________
Exercise Procedure Equipment Dosage Serratus punch Shoulder elevated to 90 degrees with elbow fully extended, move shoulder forward and back Dumbbells Low to moderate intensity, 20 reps, 1 set	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	______________________
Exercise Procedure Equipment Dosage Lower trapezius activation Lie prone on a bench, abduct both arms to about 90-120 degrees. Then turn the arm so that the thumb is pointing downwards. Then lift the arms up and down. Dumbbell Low to moderate intensity, 20 reps, 1 set	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	______________________

COOL DOWN (Stretching)

Exercise Procedure Equipment Dosage Pectoralis minor and major stretch Sitting on a wheelchair with shoulder and elbow flexed to 90 dergree, place hand against the wall, then push your trunk forward while resisting with hand on wall Wall or door 30 seconds hold	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	____
Exercise Procedure Equipment Dosage Upper trapezius and Levator scapulae stretch Sitting on a wheelchiar with shoulder in neutral, Actively depress Rt shoulder and with Lt hand, assist lateral flexion of the neck to the Lt. None 30 seconds hold	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Recommended modification (if any)	____
Exercise Procedure Equipment Dosgae Posterior capsule stretch Sitted on a wheelchair, Lift Lt arm across the body in horizontal flexion of 90 degrees and support it and increase motion with Rt arm on Lt arm's elbow. Repeat on Rt side None 30 seconds hold	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree
Exercise Procedure Equipment Dosage Sleeper stretch (external and internal rotators stretch) While lying on the Lt side with pillow between knees, take Lt shoulder out with elbow bent 90 degrees and wrist straight with fingers pointing up. Use Rt hand to slowly push Lt hand down as much as possible. Repeat on Rt side Pillow 30 seconds hold	◯ Strongly disagree ◯ Disagree ◯ Modify ◯ Agree ◯ Strongly Agree

Recommended modification (if any)	____

Appendix IV Consent Form

Informed Consent

I hereby agree to participate in the study as described in the information sheet. I also confirm that I understand the nature of the research project and I consent to participating in this study. I am aware that I won't be exposed to any risk and that I can withdrawal from the research at any time I so desire. I understand that participation is voluntary.	◯ Yes ◯ No

Please draw your signature with your mouse or finger in the space provided

Appendix V Second round questionnaire

Form 1

A A A

Welcome to round two of this Delphi study. Your input in round one was extremely valuable and appreciated.

In this round, only exercises that did not reach a consensus agreement of 80% but had a median score of 3 or more than 3 have been included.

Feedback on how all participants voted per exercise has been provided. You are allowed to mantain your previous response from round one or you can make iterations as necessary.

Thank you and Enjoy!

1) **Participant number**

* must provide value

Submit

Save & Return Later

Page 1 of 3

WARM-UP
Phase 1
Goal(s): For mobility and flexibility

Summary/Recurring themes

1. To include scapula position or stabilisation in the exercises

2. To shorten long axis of extended arm by conducting the exercises with flexed elbows first

3. To perhaps include and move exercises that involve scapular mobility from strength into the warm-up program

1

Exercise	Feedback Summary	Your Previous response	Recommended modification(s)
Exercise: Arm circles, done while sitting on a wheelchair. Procedure: Abduct arms to 90 degrees with elbows extended, then circumduct arms repeatedly for 1 minute	Endorsed by 50% (3) of the participants, the others felt that it needed modification and one participant disagreed with it. One participant felt that the long axis of the extended arm may add strain to some with existing injury or pathology	3, modify	1. Start with arm circles with flexed elbows and remind the players to set their scapula down and slightly wide. Proceed to arm circles with extended elbows once warmed up. 2. Change abduction to a PNF pattern 3. Add shoulder flexion if abduction is maintained

- maintain original response
- same exercise, change response
- select modifications to be made

reset

2

Exercise	Feedback summary	Previous response	Recommended modifications
Exercise: Chest swings Procedure: Starting with both arms adducted with elbows flexed above 90 degrees while sitted on a wheelchair, simultaneously abduct arms and retract scapula at end range, for 1 minute. Euquipment: No equipment to 1kg dumbbells after 3 weeks	While 67% (4)of the participants agreed with this warm up exercise, one thought it should be modified and one did not agree with it.	5, strongly agree	1. the scapular needs to depress as well for lower fibers of trapezius

- maintain original response
- same exercise, change response
- modification 1

reset

3

Exercise	Feedback summary	Recommended modification(s)
Exercise: Ext rotation to Int rotation Procedure: Sitted on a wheelchair with shoulder in neutral, stabilised to the body by a resistance band, then move the arm into internal rotation and then take it to external rotation, for 30 seconds Equipment: Theraband/resistance band	Endorsed by 50% (3) of the participants while two participants thought it required modification and one participant did not agree with the exercise. Your response: 5, strongly agree	1. increase dose to 1 minute 2. include detailed description of how the scapula will be stabilised during exercise

- maintain original response
- same exercise, change response
- select modifications to be made

reset

* must provide value

4

Exercise	Feedback summary	Your previous response	Recommended modifications
Exercise: Abduction and elevation Procedure: Sitted on a wheelchair, with elbows extended, raise arms into abduction and elevation for 1 minute No equipment	Endorsed by 33% (2) of the participants while two participants disagreed with it's inclusion in the program. Two other participants felt that it needed some modification	3, modify	1. focus on scapula position during exercise 2. shorten the axis by flexing the elbow 3. If elbow extension maintained, add 'palms facing up' to encourage external rotation beyond 90 degrees

- maintain original response
- same exercise, change response
- select modifications to be made

reset

* must provide value

Warm-up
Phase 2
Goal(s): To encourage correct movement patterns

Feedback summary/recurring themes

1. to perhaps create a new section before cool down, skills development section, due to the complexity of some of the exercises

2. to focus on scapula stabilisation

1

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Exercise: Back-to-back overhead passes Procedure: with a partner and wheelchairs placed back-to-back, a basketball is passed overhead between the players with elbows extended for 1 minute	Approved by 50% (3) of the participants while one participant disagrees and two feel that the exercise needs to be modified. One of the participants included the sentiment that the exercise seems to require high skill, precision and body awareness in space and so may not be suitable for warm-up, thus it may need to be moved a new	4, agree	1. move exercise to new section (skill development section before cool down) 2. Alternatively, the athletes should be placed facing each other 3. Include trunk balance and scapula position

○ maintain original response
○ same exercise, change response
○ select modifications to be made

reset

2

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Exercise: back-to-back side passes Procedure: with a partner and wheelchairs placed back-to-back, a basketball is passed side by side between the players with elbows extended for 1 minute	Approved by 50% (3) of the participants while two participants felt that it needed modification and one participant disagreed with it's inclusion in the program. The need to focus on scapula position was emphasised.	5, strongly agree	1. create and move exercise to skills development section 2. Players should have wheelchairs side by side 3. include trunk balance and scapula position

- maintain original response
- same exercise, change response
- select modifications to be made

reset

* must provide value

STRENGTHENING EXERCISES

Recurring themes

1. Scapula stabilisation

2. More focus on endurance and less on pure power

1	Exercise	Feedback summary	Your previous response	Recommended modifications	◯ maintain original response ◯ same exercise, change response ◯ select modifications to be made reset
	External rotation strength Procedure: with shoulder in neutral pressed against the body and elbow bent to 90 degrees, take hand and forearm out and then back to neutral. While sitted on a wheelchair. Equipment: dumbbell and foam or towel Dosage: 60% of 1 rep max, 6 reps, 3 sets, 30 seconds rest between sets for first 3 weeks, progressed to 80% 1 rep max after 3 weeks. Then progressed further to 10 reps, 80% 1 rep max the next 3 weeks	Approved by 50% (3) of the participants while 2 participants felt that it needed to be modified. One of the participants that suggested modifcation emphasised the need for strength endurance, not just pure power. One participant did not agree with it's inclusion in the program.	5. strongly agree	1. increase initial reps from 6 to 8 reps 2. increase reps substantially and reduce weight for 6 weeks for muscle endurance. Then add 6 reps and 1 rep max exercises after 6 weeks and rest 1 per week due to the muscle breakdown that will occur	

* must provide value

2

Exercise	Feedback Summary	Your previous response	Recommended modification(s)
Exercise: Internal rotation strength **Procedure:** with shoulder in neutral pressed against body and elbow bent to 90 degrees while carrying a dumbbell, take forearm and hand close to abdomen and then back to neutral **Equipment:** Dumbbell and foam or towel **Dosage:** 60% 1 rep max progressed to 80% 1 rep max after 3 weeks, progressed to 80% 1 rep max after 3 weeks. Further progressed to 80% 1 rep max, 10 reps, 3 sets, 30 seconds rest, next 3 weeks	Approved by 67% (4) of the participants while 2 participants felt that the exrcise needed to be modified with one participant further stressing the need for more strength endurance and not just pure power.	5, strongly agree	1. increase start reps to 8 reps from 6 reps 2. increase reps substantially and reduce weight for endurance for 6 weeks and then add 6 and 1 rep max exercises after 6 weeks. Rest 1 per week due to the muscle breakdown that will occur 3. Add various shoulder positions (Hand behind back, hand behind shoulder, and 90 degrees shoulder abduction)

○ maintain original response
○ same exercise, change response
○ select modifications to be made

reset

* must provide value

3

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Biceps curls Procedure: Shoulders in neutral and elbows 90 degrees, lift Agree forearm up. Dosage: 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for 3 weeks. 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest after 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest after 3 weeks	Approved by 67% (4) of the participants while 2 participants recommended that the exercise be modified. One of the modifications was advising to add missed 3 weeks in the initial dosage, which has been added.	3, modify	1. The player must stabilise the scapula 2. This should be done in various positions of elevation 3. Add more power endurance by increasing reps substantially and reducing weight for the first 6 weeks

- maintain original response
- same exercise, change response
- select modifications to be made

reset

* must provide value

4 **You may select multiple options except if you are maintaing your original response**

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Exercise: Scapular depression and abduction Procedure: Grab resistive band in front of wheelchair with elbow straight and depress and retract scapula Dosage: Moderate resistance, 6 reps, 3 sets, 30 seconds rest between sets for 4 weeks. Maximum resistance, 3 sets, 10 reps, 30 seconds rest between sets next 5 weeks	Approved by 67% (4) of the participants while 2 of the participants recommended modification. More focus on strength endurance over pure power was emphasised again. The other participant felt that scapula mobilisation is a very important part of shoulder care and that this exercise should be moved to the warm-up section to ensure scapulae are mobile and activated before shoulder warm ups	3, modify	1. start with very light resistance and high reps for endurance for 6 weeks 2. Move exercise to warm-up to ensure that scapula are mobile and activated before shoulder warm-ups

- maintain original response
- same exercise, change response
- select modifications to be made

reset

* must provide value

5

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Exercise: Scapular retraction Procedure: Shoulders neutral with elbows flexed 90 degrees, retract scapula while moving forearms outwards Equipment: Dumbbells Dosage: 60% 1 rep max, 6 reps, 3 sets, 30 seconds rest for 3 weeks. Progressed to 80% 1 rep max, 6 reps, 3 sets, 45 seconds rest next 3 weeks. 80% 1 rep max, 10 reps, 3 sets, 45 seconds rest next	Approved by 67% (4) of the participants while two participants recommended modifying the exercise. The sentiment of the importance of scapular mobilisation was stated again	3, modify	1. These muscles control the scapula when throwing. They need more endurance than power. Adjust reps substantially please 2. Move exercise to warm-up section to ensure that scapulae are mobile and activated before shoulder warm-ups

* must provide value

- ○ maintain original response
- ○ same exercise, change response
- ○ select modifications to be made

reset

6

Exercise	Feedback summary	Your previous response	Recommended modification(s)
Exercise: Shoulder adduction Procedure: Shoulders abducted 90 degrees, elbows extended, pull resistance band close to your body and return to starting position Equipment: Resistive band Dosage: Moderate resistance, 6 reps, 3 sets, 30 seconds for 4 weeks. maximum resistance, 10 reps , 3 sets, 30 seconds rest for the next 5 weeks	Approved by 67% (4) of the participants while 2 participants recommended that the exercise be modified. one of the recommended modifications was to correct the spelling of resistance which has been corrected.	3, modify	1. this needs to cross midline for functional application

◯ maintain original response
◯ same exercise, change response
◯ modification 1

reset

* must provide value

Close survey

Thank you for taking the survey.

Have a nice day!

Enter your email to receive confirmation message?
A confirmation email is supposed to be sent to all respondents that have completed the survey, but because your email address is not on file, the confirmation email cannot be sent automatically. If you wish to receive it, enter your email address below.

Enter email address | Send confirmation email

* Your email address will not be associated with or stored with your survey responses.

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Appendix VI Feedback summary of round 1

DESCRIPTIVE STATS SUMMARY

WARM-UP

The table below shows the number of participants who voted for each option, strongly disagree, disagree, modify, agree, and strongly agree, for each exercise in the warm-up section. All the exercises in the warm-up section did not reach a consensus agreement rate which was set at 80%. However, because all of them have a median score of ≥3, their recommended modifications will be presented in the second round of the Delphi. The group's median score and frequency of agreement are also presented in the table.

Exercise	**Strongly disagree (1)**	**Disagree (2)**	**Modify (3)**	**Agree (4)**	**Strongly agree (5)**	**Group's median score**	**Frequency of agreement**
Arm circles	1	0	2	3	0	3.5	50%
Chest swings	1	0	1	3	1	4	67%
External rotation to internal rotation	1	0	2	1	2	3.5	50%
Abduction and elevation	2	0	2	2	0	3	33%
Back-to-back overhead passes	1	0	2	3	0	3.5	50%
Back-to-back side passes	1	0	2	2	1	3.5	50%
Forward and backward wheelchair propulsions	1	0	1	2	2	4	67%

STRENGTHENING EXERCISES

Out of the 9 strengthening exercises, 3 exercises presented in green, reached a consensus agreement of ≥80% and so will be excluded from round 2 of the Delphi. The remaining 5 exercises all have a median score of ≥3 and will therefore be fed back to the panel, with the recommended modifications.

The table below provides a descriptive summary of how panel members rated the strengthening exercises. The number of participants that voted for each option (strongly disagree, disagree, modify, agree, and strongly agree) is shown. The group's median score and frequency of agree and strongly agree are also presented in the table.

Exercise	Strongly disagree	Disagree	Modify	Agree	Strongly Agree	Group's Median Score	Frequency of agree and strongly agree
External rotation strength	1	0	2	1	2	3.5	50%
Internal rotation strength	0	0	2	2	2	4	67%
Serratus anterior strength	0	0	1	3	2	4	83%
Biceps curls	0	0	2	3	1	4	67%
Scapular depression and abduction	0	0	2	3	1	4	67%
Scapular retraction	0	0	2	2	2	4	67%
Shoulder adduction	0	0	2	1	3	4.5	67%
Chest press (pectoralis major)	0	0	1	2	3	4.5	83%
Lat pull up	0	0	1	4	1	4	83%

SCAPULAR STABILISERS ACTIVATION

2 out of 3 exercises of activating scapular stabilisers reached a consensus of ≥80% agreement. The one exercise that did not has a median score of 4 and so will be included in round 2 of the Delphi with the recommended modification.

The table below shows a summary of the number of panel members voted for each category (strongly disagree, disagree, modify, agree, and strongly agree) for each exercise.

Exercise	Strongly disagree	Disagree	Modify	Agree	Strongly agree	Median	Frequency

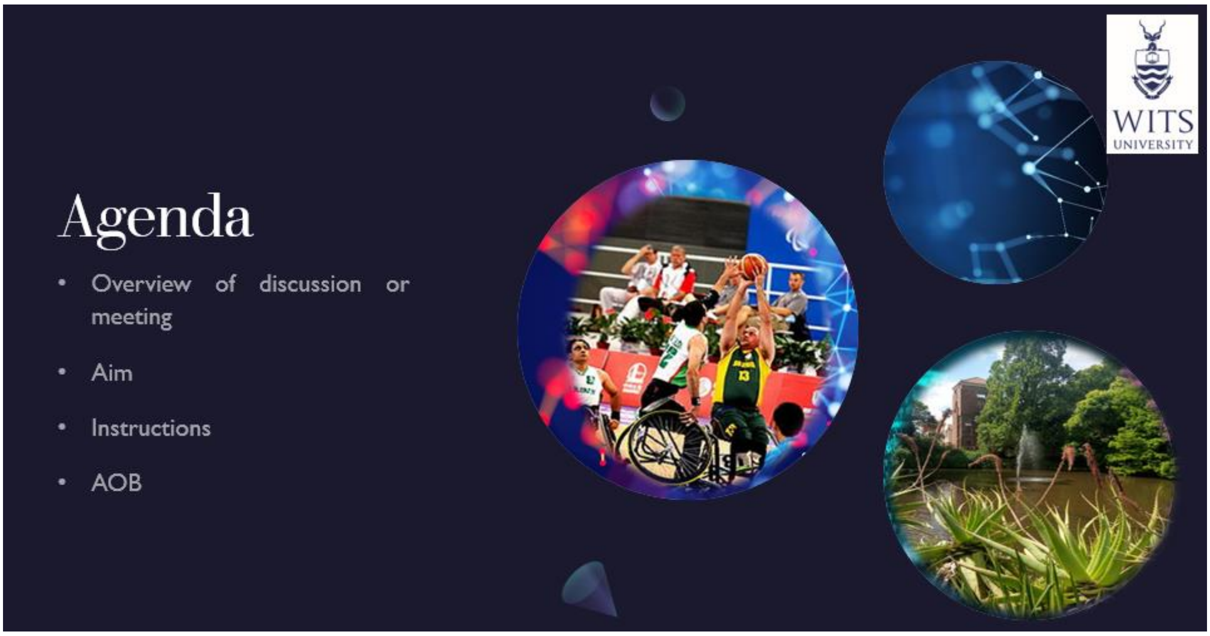
Y's, t's and w's	0		2	2	2	4	67%
Serratus punch	0		1	3	2	4	83%
Lower trapezius activation	0		1	4	1	4	83%

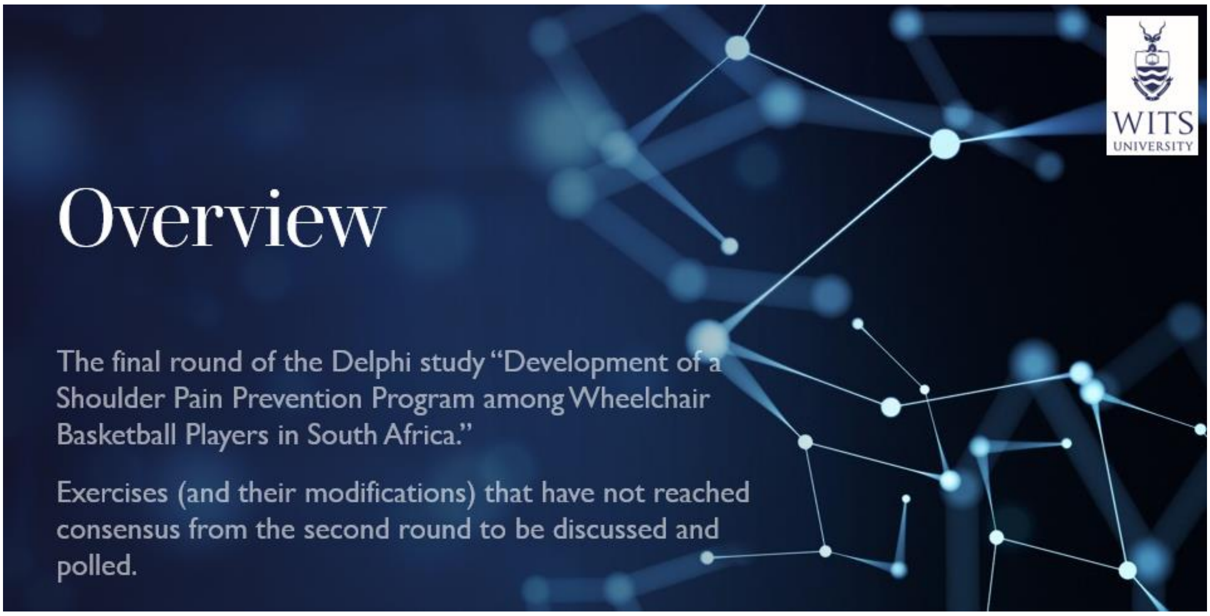
COOL DOWN (STRETCHING)

All 4 stretches in the cool down section reached a consensus of ≥80% agreement and so will not be included in round two of the Delphi. Some recommended modifications will be discussed in the third round. Below is a table presenting a summary of the number of panel members who voted for each category (strongly disagree, disagree, modify, agree, and strongly agree), the group's median score and the frequency of agreement.

Exercise	**Strongly disagree**	**Disagree**	**Modify**	**Agree**	**Strongly agree**	**Group's median score**	**Frequency of agreement**
Pectoralis major and minor stretch	0	0	1	5		4	83%
Upper trapezius and levator scapulae stretch	0	0	1	5		4	83%
Posterior capsule stretch	0	0		5	1	4	100%
Sleeper stretch	0	0		4	1	4	83%

Appendix VII PowerPoint presentation




WITS
UNIVERSITY
Overview
The final round of the Delphi study "Development of a Shoulder Pain Prevention Program among Wheelchair Basketball Players in South Africa."
Exercises (and their modifications) that have not reached consensus from the second round to be discussed and polled.


WITS
UNIVERSITY
Aim
To reach consensus agreement on exercises to be included in the program for prevention of shoulder pain among wheelchair basketball players. Exercises that do not reach consensus will be excluded from the final program.


WITS
UNIVERSITY
How meeting will be conducted
Each participant given a minute to comment on an exercise. Then participants allowed to exchange thoughts on the exercise (speaking in turns by raising hand). Discussions to revolve around the ideas that have already been raised in the Delphi process and not new ideas because of time limitations for the research.
Then voting for the exercise to be included or excluded in the final program.


How meeting will be conducted
WITS UNIVERSITY
Proceed to next exercise until phase is completed.
Then confirm areas of agreement in a phase before proceeding to next phase.
Repeat procedure in the next phase.
Conclude meeting.


Thank You

Appendix VIII Summary form from second round

SECOND ROUND, DESCRIPTIVE STATISTICS SUMMARY

5 participants participated in the second round. 1 participant maintained their responses from the first round while the other participants made some adjustments in some areas based on the feedback that was provided. The table below provides a summary of the responses by all the participants.

Exercise	**Participant 07**	**Participant 08**	**Participant 09**	**Participant 10**	**Participant 12**
Arm circles	Maintained-disagree	Maintained-agree	Mod: 2 (change abduction to PNF pattern) Do both D1 and D2 and include the flexion and extension	Mod: 2 (change abduction to PNF pattern) D2 shoulder extension pattern	Mod: 1 (start with elbows flexed, remind players to set scapula down and slightly wide. Proceed to arm circles with extended elbows once warmed up)
Chest swings	Maintained-disagree	Maintained-agree	Mod: 1 (the scapular needs to depress as well for lower fibers of trapezius)	Maintained: agree	Mod: 1 (the scapular needs to depress as well for lower fibers of trapezius)
Ext rotation to Int rotation	Maintained-disagree	Modifications: 1 (increase dose to 1 minute) & 2 (include detailed description of how scapula will be stabilised)	Mod: 2 (include detailed description of how scapula will be stabilised) Add picture to help them visualise	Mod: 2 (include detailed description of how scapula will be stabilised)	Mod: 1 (increase dose to 1 minute) & 2 (include detailed description of how scapula will be stabilised)
Abduction and elevation	Maintained-strongly disagree.	Modifications: 3 (if elbow extension is	Mod: 1 (focus on scapula position during exercise) ,2	Mod: 2 (shorten axis by	Mod: 2 (shorten axis by flexing elbow)

Exercise	Participant 07	Participant 08	Participant 09	Participant 10	Participant 12
		maintained, add palms facing up to encourage external rotation beyond 90 degrees)	(shorten axis by flexing elbow) & 3 (if elbow extension is maintained, add palms facing up to encourage external rotation beyond 90 degrees) Use picture as well to visualise scapula position	flexing elbow)	
Back-to-back overhead passes	Maintained -strongly disagree	Modifications: 1 (the athletes should be placed facing each other) & 2 (move exercise to new section, skills development section after cool-down)	Mod: 1 (the athletes should be placed facing each other), 2 (move exercise to new section, skills development section after cool-down) & 3 (include trunk balance and scapular position)	Maintained: agree	Mod: 1 (the athletes should be placed facing each other), 2 (move exercise to new section, skills development section after cool-down) & 3 (include trunk balance and scapular position)
Back-to-back side passes	Maintained-strongly disagree.	Mod: 1 (create and move exercise to skills development section) & 2 (players should have wheelchairs	Mod: 1 (create and move exercise to skills development section), 2 (players should have wheelchairs side-by-side) & 3	Maintained: agree	Mod: 1 (create and move exercise to skills development section), 2 (players should have wheelchairs

Exercise	Participant 07	Participant 08	Participant 09	Participant 10	Participant 12
		side-by-side)	(include trunk balance and scapular position)		side-by-side) & 3 (include trunk balance and scapular position)
Ext rotation strength	Maintained - strongly agree	Mod 1: (increase initial reps from 6 to 8 reps)	Mod: 2 (increase reps substantially and reduce weight for 6 weeks for muscle endurance, then add 6 reps and 1 rep max exercises after 6 weeks and rest 1 per week due to the muscle breakdown that will occur) Dosage 3: 2kg dumbbells, 20 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks	Maintained: Strongly agree	Mod: 2 (increase reps substantially and reduce weight for 6 weeks for muscle endurance, then add 6 reps and 1 rep max exercises after 6 weeks and rest 1 per week due to the muscle breakdown that will occur) Dosage 2: 2kg dumbbells, 15 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Int rotation strength	Maintained- agree	Mod: 1 (increase initial reps from 6 to 8 reps)	Mod: 2 (increase reps substantially and reduce weight for 6 weeks for muscle endurance,	Maintained: Strongly agree	Mod: Does not indicate the modification

Exercise	Participant 07	Participant 08	Participant 09	Participant 10	Participant 12
			then add 6 reps and 1 rep max exercises after 6 weeks and rest 1 per week due to the muscle breakdown that will occur) & 3 (Add shoulder positions; hand behind back, hand behind shoulder and 90 degrees shoulder abduction)		
Biceps curls	Maintained - agree	Maintained – strongly agree	Mod: 1 (the player must stabilise the scapular),2 (should be done in various positions of elevation) & 3 (add more power endurance by increasing reps substantially and reducing weight for the first 6 weeks)	Maintained-agree	Mod: 1(the player must stabilise the scapular) & 3 (add more power endurance by increasing reps substantially and reducing weight for the first 6 weeks)
Scapular depression and abduction	Maintained-agree	Mod: 2 (move exercise to warm-up to ensure that scapulae are mobile and	Mod: 1 (start with very light resistance and high reps for endurance for 6 weeks) & 2 (move exercise to	Maintained-strongly agree	Mod: 1 (start with very light resistance and high reps for endurance for 6 weeks) & 2

Exercise	Participant 07	Participant 08	Participant 09	Participant 10	Participant 12
		activated before shoulder warm-ups)	warm-up to ensure that scapulae are mobile and activated before shoulder warm-ups)		(move exercise to warm-up to ensure that scapulae are mobile and activated before shoulder warm-ups)
Scapular retraction	Maintained-agree	Mod: 2 (move exercise to warm-up to ensure that scapulae are mobile and activated before shoulder warm-ups)	Mod: 1 (these muscles control the scapula when throwing. They need more endurance than power. Increase reps substantially)	Maintained-strongly agree	Mod: 1 (these muscles control the scapula when throwing. They need more endurance than power. Increase reps substantially) & 2 (move exercise to warm-up to ensure that scapulae are mobile and activated before shoulder warm-ups)
Shoulder adduction	Maintained-strongly agree	Maintained-strongly agree	Mod: 1 (this needs to cross midline for functional application)	Maintained-strongly agree	Mod: 1 (this needs to cross midline for functional application)

Appendix IX Human Research Ethics Committee approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Miss Tawina FF Msadala

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200907

NAME: (**Principal Investigator**) Miss Tawina FF Msadala

DEPARTMENT: Physiotherapy

PROJECT TITLE: Development of a shoulder pain prevention programme for wheelchair basketball players in South Africa

DATE CONSIDERED: 02/10/2020

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Mr S. Kunene

APPROVED BY: CB Penny

Dr CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 20/11/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **October** and will therefore be due in the month of **October** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

____
Principal Investigator Signature

____
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix X Turnitin report

ORIGINALITY REPORT

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Introduction

1.1 Background

Participation and watching of Paralympic sports has increased over the years, with WB said to be the most common Paralympic sport (Heyward et al., 2017). More than 200 athletes participated in WB in London and Rio Paralympic games, making it the sport with the fourth and third highest number of athletes participating respectively (Willick et al., 2013; Derman et al., 2018). This has proven to be true in South Africa as well. Lepera (2010) suggests that the recent increase in participation in WB in South Africa over the years may be owed to the recent success of local athletes at foreign clubs and increased sponsorship in the sport locally. The Supersport WB series, a televised yearly tournament in which the top six teams in the country participate, is one of the developments that arose with the availability of funds (Lepera, 2010; Mateus & Pillay, 2019).

Essentially, with the increased participation in WB, it is necessary to understand the sport itself. WB has been described as a high intensity sport that involves fast wheelchair propulsion manoeuvres including acceleration, pivoting, quick start and stops for attack and defensive work, and overhead activities including quick passing, shooting and rebounding (Goosey-Tolfrey, Butterworth & Morriss, 2002; Lepera, 2010).

Historically, WB was established for injured soldiers in 1942 during the second World War (Gómez, 2018). In 1948, the first wheelchair sports competition, the Stoke Mandeville games including WB among other wheelchair sports, was organised by Sir Ludwig and his colleagues. Following that, the International Stoke Mandeville games were established a couple of years later. The paralympic games were established in 1960 and have since become the main international sporting event for athletes with physical disabilities (Gómez, 2018).

The benefits of participating in sports for people with disabilities are immense. Firstly, sport participation promotes health and physical fitness for people with disabilities much like their able-bodied counterparts or sometimes even more (Burnham et al., 1993). For example, WB players, are reported to have a well-developed upper body that is stronger than regular basketball players due to involvement of the upper limbs in daily function as well as sports (Burnham et al., 1993). Physiological adaptations, including increased rate of oxygen consumption ($V0_2$) and improved extraction of oxygen from blood into cells for use resulting in improved cardiovascular endurance, have been reported for people with spinal cord injuries

participating in endurance sports (Vanlandewijck & Thompson, 2011). Brukner & Khan (2017) reported that people with disabilities participating in sports had much less hospital visits than their counterparts that were not physically active. In addition, the psychosocial benefits of participation may be even bigger. Athletes with disabilities have reported finding a sense of identity, improved social and interpersonal relationships, boosted self-esteem, confidence and sense of accomplishment, feelings of liberty and freedom to be themselves regardless of their disability, and reduction of stress and anxiety, among others (Vanlandewijck & Thompson, 2011; Jefferies, Gallagher & Dunne, 2012; Aitchison et al., 2022).

Conversely, injuries occur in sports including para sports. Generally, athletes with disabilities tend to have a lot of overuse injuries of the upper limb, with shoulder injuries considerably more common than injuries in any other anatomical area (Willick et al., 2013; Derman et al., 2018; Dutton, 2019). Other common upper extremity injuries among athletes with disabilities include nerve entrapment injuries, with carpal tunnel syndrome a regular culprit (Dutton, 2019). Repetitive trauma from repetitive high strain on the shoulder and repetitive wrist flexion and extension respectively, during manual wheelchair propulsion and transfers has been reported to be associated with these types of injuries (Vanlandewijck, Theisen & Daly, 2001; Dutton, 2019). Additionally, para-athletes tend to have reduced bone mass density predisposing them to fractures (Dutton, 2019). Furthermore, unlike able-bodied athletes, athletes with disabilities are at risk of pressure sores from sweating during sports among other factors and autonomic dysreflexia for spinal cord injury (SCI) athletes below level T6 (Dutton, 2019).

Similarly, in WB, upper limb injuries are common with the shoulder being the most commonly injured anatomical area. Wheelchair basketball players are involved in overhead activities and

Similarly, in WB, upper limb injuries are common with the shoulder being the most commonly injured anatomical area. Wheelchair basketball players are involved in overhead activities and continuous use of the upper limbs for manoeuvring the wheelchair when chasing after other athletes and making quick turns and stops. These activities may overwork the shoulder thereby increasing the chance of developing pain (Lepera, 2010; Heyward et al., 2017; Mateus & Pillay, 2019).

In addition to overhead activities, WB players are in involved in repetitive hand rim propulsion of a wheelchair during training, competition, sports and for some during activities of daily living (ADL's). The repetitive nature of this may cause fatigue to the rotator cuff and some other shoulder muscles. Moreover there are high forces at the shoulder during hand rim propulsion which may expose the shoulder to injury (Van Der Woude et al., 2001; Vanlandewijck, Theisen

& Daly, 2001). Poor sitting posture in the wheelchair associated with trunk control may also lead to development of SP (Mateus & Pillay, 2019).

Basically, several risk factors have been associated with shoulder pain (SP) with regards to repetitive wheelchair propulsion mechanics and overhead activities among WB players. Among them are reduced internal rotation range of motion, tightness of posterior structures of the shoulder and muscle imbalances (Wilroy & Hibberd, 2018; Christiana, 2019). Poor trunk control and exercise load were also found to have an effect on SP for WB players in Johannesburg (Christiana, 2019).

In order to earnestly understand the extent of an injury problem, incidence rate should be reported. Unfortunately, in my knowledge, prospective studies have not been conducted with regards to incidence of SP among WB players. However, the incidence of shoulder injuries at the London and Rio Paralympic games among athletes with disabilities in general was reported to be higher than other anatomical regions, with incidence rates of 10.5 and 1.8 per 1000 athlete days respectively (Willick et al., 2013; Derman et al., 2018).

That being said, multiple cross-sectional studies have been done reporting the prevalence rate of SP among WB players. Varying ranges of prevalence have been reported with ranges starting from 21% (Heyward et al., 2017). In South Africa similarly, high prevalence rates have been reported (Lepera, 2010; Christiana, 2019; Mateus & Pillay, 2019). In the Supersport WB series, 54% of the athletes had suffered SP since the start of their career and 44% in the year prior to the study (Mateus & Pillay, 2019).

With high prevalence of shoulder injuries, most research has not focused on injury prevention (Heyward et al., 2017). However, studies that did, have recommended that exercises would be beneficial in the prevention of SP for athletes with disabilities (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). Wilroy et al (2018) and García-Gómez et al (2017) suggest that a strengthening and stretching program may improve the characteristics that increase the risk of developing SP (Wilroy & Hibberd, 2018). While several literatures have identified the epidemiology of shoulder injury in WB, few have looked at prevention of shoulder pain for WB players and none has developed an injury prevention programme in South Africa. This study therefore aims to develop an exercise programme suitable for the prevention of shoulder pain for WB players in Johannesburg.

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1.2 Problem statement

Shoulder injury is a common problem in wheelchair basketball (Heyward et al., 2017; Mateus & Pillay, 2019). With participation and popularity of the sport increasing, it is necessary to prevent shoulder injuries as they affect participation in sports including WB and negatively impact the quality of life of athletes (Vanlandewijck & Thompson, 2000). Generally, studies focusing on SP in wheelchair sports including WB are scarce (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). In South Africa, recent research has focused on the epidemiology of shoulder injuries and identifying the associated risk factors. In addition to the scarcity of research on SP prevention strategies in WB, no study has developed an exercise programme to prevent such common injuries in South Africa and Sub-Saharan Africa (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). This study therefore aims to outline the range of preventive strategies available and to develop an exercise programme for the prevention of shoulder injuries in WB players in South Africa.

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1.3 Aims and objectives

1.3.1 Aim

To map the range of strategies to prevent shoulder injuries and develop an exercise programme for the prevention of shoulder pain among wheelchair basketball players in South Africa through an expert-based consensus.

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1.3.2 Objectives

i. To conduct a scoping literature review on current preventive strategies for shoulder pain in overhead sports.
ii. To identify suitable exercises to be included in the shoulder pain prevention programme for wheelchair basketball players.

programme for wheelchair basketball players.

iii. To obtain experts' consensus on exercises to be included in the shoulder pain prevention programme for wheelchair basketball players.

1.4 Significance

Shoulder pain not only negatively affects performance in WB sport; it also negatively impacts the quality of life for WB players that are wheelchair users because they use their upper limbs for activities of daily living (ADLs) including mobility and transfers. Moreover, the most common disability in WB, spinal cord injury, predominantly renders people wheelchair users. So, in essence a lot of WB players' quality of life is affected because of SP. However, research on preventive measures is scarce. Most studies have focused on the epidemiology of SP as opposed to focusing on prevention. Therefore, there is need to conduct more research in this area, hence the need for this study. This study may help coaching teams effectively implement their training strategies with prevention of SP also being focused on. It may also potentially help WB players learn prevention strategies for SP and provide information to learners to explore this topic further by conducting experimental studies to evaluate the effectiveness of the SP prevention programme among WB players.

Outline of this research report

The outline for the research report is illustrated in figure 1.1 below, from the first chapter; introduction all the way to chapter 6; conclusion and recommendations and references and appendices.

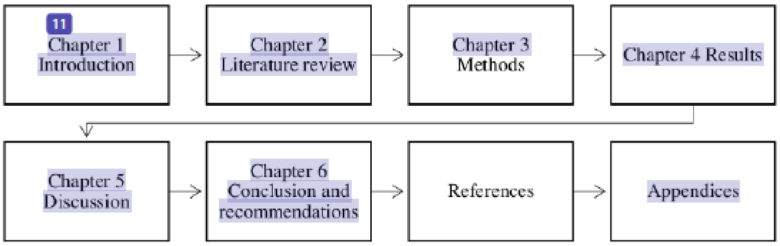

Figure Error! No text of specified style in document.**.1 Outline of research report**

Literature Review

1.5 Introduction

Shoulder pain (SP) poses a significant challenge among WB players, that the need for its prevention cannot be over emphasised. This review will begin by providing insight into the rules and mechanics of WB to better guide the reader into understanding why SP is so prevalent in the sport. Then, following the systematic approach to injury prevention, as described by van Mechelen, Hlobil & Kemper (1992) further developed by Finch (2006) and Bolling et al (2018), this chapter will establish the extent of the SP problem in WB, the risk factors associated with it and the preventive measures that have been discussed and implemented thus far. Because the focus of this study is prevention of SP in WB, SP in other disability sports will only be mentioned as necessary in this review.

1.6 Search strategy

Pubmed and Ebsco Host (incorporating Medline, SportDiscus and CINAHL) were searched through the University of Witwatersrand library. Keywords used were shoulder pain or injury, wheelchair basketball, injury prevention or injury prevention program, and wheelchair basketball biomechanics. Articles found from references were searched on Googlescholar.

1.7 Wheelchair basketball rules

Wheelchair basketball is a high intensity sport played that is played on a hard court and consists of four quarters each lasting ten minutes, with very little breaks in between except half-time, which has a longer break of fifteen minutes. Each side consists of 5 players playing at any given moment, with a maximum of 14 points per team allowed during any match (IWBF Executive Council, 2021). In this section, the classification of WB is discussed.

1.7.1 Classification of wheelchair basketball players

WB players have a diverse range of disabilities that can be grouped into neurological and musculoskeletal disabilities (Van Der Woude et al., 2001). Neurological disabilities among WB players include spinal cord injury, cerebral palsy, and poliomyelitis among others. The most notable musculoskeletal disability is limb deficiency (Van Der Woude et al., 2001; IWBF, 2021).

Because of the variety of conditions that WB players present with, classification is done to group the players according to their function and overall ability. The classification system ensures that there is a balance in the functional capabilities of the teams and that they out-

perform each other based on their skill(s) as opposed to their impairments. It is also done to determine a player's the eligibility to participate in a WB tournament (IWBF Executive Council, 2021).

Generally, players are classified on an 8-point classification system with an interval of 0.5, by classifiers officially trained by the International Federation of Wheelchair Basketball (IWBF). Each class (Figures 2.1 and 2.2) has unique characteristics depending on their trunk, and upper and lower limb function. The method used to classify players is termed the volume of action which is defined as the extent that a player can freely move their trunk and hands in any direction and return back to their original upright position, without holding their wheelchair for support (IWBF, 2021).

So, using the volume of action, class 1.0 and 2.0 players (Figure 2.1 below) require the use of their hands to return to an upright seating position once unbalanced. Yildirim, Comert & Ozengin (2010) grouped these classes together and referred to all players classified below three as low point players. Generally, these players have no active pelvic stability and so require passive stabilisation (IWBF Executive Council, 2021). However, there are some differences in these two groups as well. Class 1.0 players have no active trunk control and movement in rotation and bending forward or sideways (left or right). These players are said to have the least volume of action. Meanwhile, class 2.0 players have partial volume of action in trunk rotation and forward bending. They, however, have no control in bending of their trunk to the left or right and they can hold the ball with both of their arms outstretched (IWBF Executive Council, 2021).

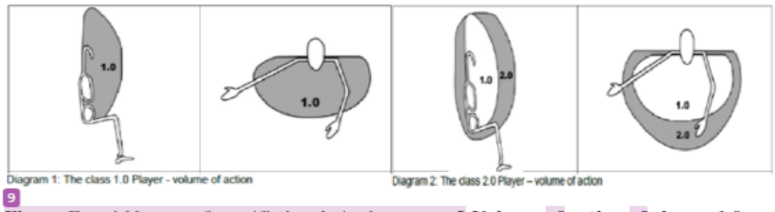

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Figure Error! No text of specified style in document.**.2 Volume of action of classes 1.0 and 2.0 (IWBF, 2021)**

In contrast, players classified above 3.0 (figure 2.2) have been termed as high point players (Yildirim, Comert & Ozengin, 2010) and they generally have active pelvic stability (IWBF Executive Council, 2021). Class 3.0 players have complete forward trunk movement and rotation, and can return upright from forward bending without use of their hands. They, however, have no controlled trunk movement when bending sideways and so require use of one hand at least to return to an upright sitting position from a sideways position. While class 4.0 players also have complete trunk movement and control in forward bending and rotation, they differ from class 3.0 in that they have complete trunk movement laterally to one side (left or right). They can hold the ball over their head without loss of stability. Finally, Class 4.5 players have complete trunk movement in all sides in addition to trunk rotation and forward and backward movement. In circumstances where a player does not seem to fit a single category, they are classified using a 0.5 basis, placing them in classes 1.5, 2.5 or 3.5.

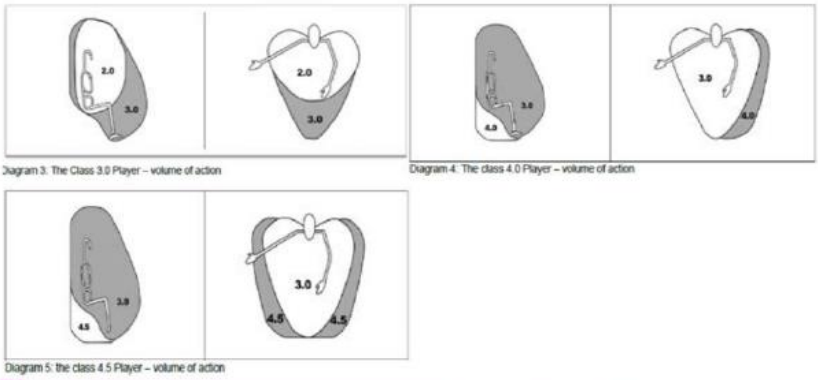

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Figure Error! No text of specified style in document.**.3 Volume of action of WB players ≥ 3.0 (IWBF, 2021)**

On the other hand, as opposed to the volume of action, WB players with limb deficiencies are classified based the level of the amputation and whether they are amputated on both left and right sides (Figure 2.3) (IWBF Executive Council, 2021).

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Figure Error! No text of specified style in document.**.4 classification of WB players with limb deficiencies (IWBF, 2021)**

Shoulder pain in wheelchair basketball

Shoulder pain can originate from any of the structures of the shoulder joint. In WB, it has been associated with a number of pathologies commonly rotator cuff tear and injuries and impingement syndrome cause SP (Burnham et al., 1993; Lepera, 2010; Heyward et al., 2017). According to some studies, no relationship was established between SP and the type of disability even though spinal cord injuries or lesions and poliomyelitis were the most common disabilities in WB (Lepera, 2010; Christiana, 2019).

Epidemiology of shoulder pain in wheelchair basketball

To establish the severity of a problem, incidence and severity of the said problem in the context being discussed should be established (Chalmers, 2002). While incidence rates have not yet been established in South Africa, the prevalence rates of SP reported in WB are generally high.

Christiana (2019) in her study on shoulder pain and its risk factors among WB players in Johannesburg reported a point prevalence of 52% and a prevalence of 72% during wheelchair use. The high point prevalence may be explained by the fact that this study was conducted at the end of the basketball season. Lepera (2010) on the other hand found a point prevalence of 37.9% and 72.4% since using a wheelchair use. Lepera conducted her study just before the beginning of the WB season which could explain the differences in the point prevalence. While both studies were conducted among Gauteng based WB players, Mateus & Pillay (2019) may be a little more representative because their study involved WB players in the Supersport League games who are based from all over the country. The prevalence of SP since the start of their WB career was reported to be 54% and 44% in the previous twelve months, and was associated with an occasion during WB game or training (Mateus & Pillay, 2019). Wheelchair propulsion and overhead activities have been reported to aggravate SP the most (Lepera, 2010; Mateus, 2015).

All the three studies above were cross sectional studies that used questionnaires that were validated and tested for reliability through experts and pilot studies. Cross sectional studies are the best for measuring prevalence (Portney & Watkins, 2015). They are however subject to recall bias. Their small sample sizes with the maximum being forty-eight WB players (Mateus and Pillay), may not be representative of the country but they provide an insight into arguably the most advanced WB league in South Africa.

1.7.2 Risk factors associated with shoulder pain in wheelchair basketball

It is common knowledge that both high- and low-point players are at risk of developing SP (Curtis & Black, 1999; Lepera, 2010; Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016; Christiana, 2019; Mateus & Pillay, 2019). The intensity of pain and the mechanisms by which these two groups develop SP are what have been reported to be different. While some studies have reported that high-point players have higher intensity of SP (Curtis & Black, 1999; Christiana, 2019), others have established that low point players have more SP compared to high point players (Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016).

In terms of the mechanisms that lead to development of SP, low point players are said to have high load on the shoulder from wheelchair use and transfers during training and basketball as well as their daily lives (Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016). On the other hand, high point players may have more pain because of repetitive stress from overhead activities associated with shooting and passing the ball which they seem to take more responsibility for by virtue of their good strength in the trunk (Curtis & Black, 1999). Regardless of the mechanism however, it is clear that both groups have a SP problem.

Several risk factors, intrinsic and extrinsic, have been associated with SP. Intrinsic risk factors include muscle imbalances, posture, range of motion and flexibility (Burnham et al., 1993; Curtis & Black, 1999; Lepera, 2010; Aytar et al., 2015). Extrinsic factors associated with SP in WB include years of wheelchair use and propulsion techniques. Improved mechanics of propulsion have been recommended (Lepera, 2010; Yildirim, Comert & Ozengin, 2010; Christiana, 2019).

Muscle imbalances have been mainly associated with WB players with low trunk control. Burnham et al (1993) found weakness of shoulder adductors compared to abductors in WB players. This pattern was reported to be different from swimmers and other overhead sports where shoulder adductors were stronger than abductors (Burnham et al., 1993). In addition to this, WB players have been associated with overuse and tear of the rotator cuff muscles as they are overworked in their role to stabilise the shoulder (Heyward et al., 2017; Wilroy & Hibberd, 2018; García-Gómez et al., 2019). When they get fatigued, the rotator cuff muscles fail to maintain humeral head in the glenoid fossa during motion of the shoulder. Because of the strength imbalance between shoulder adductors and abductors, there is an increased risk of the humeral head being pulled upward during motion. This superior translation of the humeral head may lead to impingement syndrome (Heyward et al., 2017). In addition to this, because of wheelchair propulsion, pectoral muscles have also been reported to be much stronger than posterior shoulder muscles (Curtis & Black, 1999).

With regards to posture, due to reduced trunk and pelvic control, low point players sit in a wheelchair with the pelvis tilted posteriorly leading to compensatory hyper kyphosis of the thoracic spine, protraction of the scapula and forward movement of the shoulders and head. This causes posterior structures including scapular stabilisers to elongate and weaken, and structures on the front including pectoralis minor to shorten and tighten (Burnham et al., 1993; Curtis & Black, 1999; Aytar et al., 2015; García-Gómez et al., 2019). Furthermore, significant reduction in internal rotation (IR) range of motion (ROM) of more than fifty degrees and slight increment in external rotation (ER) ROM have been reported (Burnham et al., 1993; Curtis & Black, 1999; Wilroy & Hibberd, 2018; Christiana, 2019). This has also been associated with altered sitting posture resulting in tightening of anterior structures, reduced flexibility, and compensatory lengthening of posterior structures (Aytar et al., 2015). Interestingly, altered

kinematics of the shoulder may also be as a result of a protective mechanism as the body chooses the movement patterns that will cause less pain (Briley et al., 2021).

Biomechanics of the shoulder joint

The mechanisms that lead to the development of SP among WB players can be partially explained through the biomechanics of the shoulder joint. In fact, in WB, SP has been associated with the structure and function of the shoulder joint itself. The shoulder girdle, unlike the pelvic girdle of the lower extremities, is structured to allow high amounts of mobility (Veeger & van der Helm, 2007). The ball and socket of the glenohumeral joint (GH) is made such that the head of the humerus is much larger than its articulating surface, the glenoid fossa. Figure 2.4 below illustrates this concept.

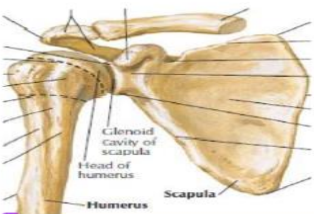

Figure Error! No text of specified style in document..5 **GH joint (Netter Frank, 2018)**

High mobility of the shoulder joint is further explained by the loose connection of the scapula to trunk, making it able to slide and rotate on the rib cage during glenohumeral motion (Veeger & van der Helm, 2007). Scapula motion is said to be responsible for about a third of total elevation of the arm. During elevation as the humerus elevates, the scapular contributes to the movement by rotating laterally in a mechanism called the scapulohumeral rhythm (Fig 2.5 below) (Veeger & van der Helm, 2007).

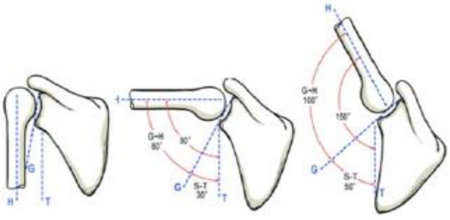

Figure Error! No text of specified style in document.**.6 scapulohumeral rhythm (kovacevic, 2012)**

WB players however, have been reported to present with scapular dyskinesis, where the scapular is translated laterally at rest (Aytar et al., 2015). This translation of the scapular at rest and a typical posture of posterior pelvic tilt, increased thoracic kyphosis and a forward head posture with an anteriorly displaced shoulder girdle in individuals that use a manual wheelchair in their everyday lives including sports, may lead to weakness of scapulothoracic muscles and shoulder pain (Aytar et al., 2015; Soo Hoo, 2019). On the other hand, this "typical" posture may also be brought about by weakness of scapulothoracic muscles (Aytar et al., 2015). Scapulothoracic muscles, especially the serratus anterior and rhomboid muscles, stabilise the scapula during forward flexion/elevation of the arm. When weakened due to altered scapular movement and position, they impact normal function on the shoulder. The serratus anterior is also the main muscle that generates torque (propulsive force) during elevation (Veeger & van

With all the mobility however, the shoulder joint is quite equipped for stability as well. Because of its complexity, the shoulder has been recognised as a specialty within sports medicine (Wilroy & Hibberd, 2018). The rotator cuff muscles are important dynamic stabilisers of the shoulder joint, and they function to maintain the humeral head in the glenoid fossa during motion (Lugo, Kung & Ma, 2008; Rathi, Taylor & Green, 2016).

Experiments conducted on muscle activity during hand rim wheelchair propulsion show that the rotator cuff muscles, especially the supraspinatus, are active during the entire wheelchair propulsion cycle (Vanlandewijck, Theisen & Daly, 2001; Boninger et al., 2002). They are therefore prone to fatigue which could eventually lead to SP (Heyward et al., 2017).

Finally, because of the deficit in the kinetic chain with the lower body unable to assist in force production during manual wheelchair propulsion, the shoulder has to produce high propulsive forces (Heyward et al., 2017; Fairbairn & Bliven, 2019). Therefore, during the game, training and ADLs, the shoulder is repetitively overloaded leading to overuse of muscles (Heyward et al., 2017).

Biomechanics of wheelchair basketball

Biomechanics of WB provide insight into the load and mechanisms that may lead to shoulder pain among WB players, making it vital to address. This section will discuss general hand rim wheelchair propulsion biomechanics as it relates to WB and specific dynamics for WB, and the association between the biomechanics and SP.

Hand rim wheelchair propulsion biomechanics

Studies researching hand rim wheelchair propulsion have mostly been simulations of the task and its dynamics because it is difficult to study wheelchair propulsion biomechanics under real life conditions (Vanlandewijck, Theisen & Daly, 2001). However important information related to load and mechanisms on the shoulder have been discussed. In this review, only information from simulation studies that used a treadmill or dynamometer are included because they simulate close to real life as compared to a stationery ergometer (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

In WB, not all players use a wheelchair for daily activities. However, all players use a wheelchair for sports (Vanlandewijck, Theisen & Daly, 2001; IWBF, 2021) and so all players perform manual wheelchair propulsion at a certain level. In fact, some studies have reported that more 60% of a match consists of propulsive action (Vanlandewijck, Theisen & Daly, 2001; Seron, Oliveira De Carvalho & Greguol, 2019), hence the necessity for discussing this.

Hand rim wheelchair propulsion is a repetitive process, and the propulsion cycle consists of the push and recovery phases. During the push phase, a wheelchair user's hand makes contact with the rims of a wheelchair and apply propulsion force. The recovery phase is a phase when the user's hands are not in contact with the rims and are preparing for contact (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

Both the push and recovery phases are active phases, meaning that shoulder muscles are actively working in each phase. In the push phase, shoulder muscles are working to produce

propulsive force. Shoulder flexors, anterior deltoid and pectoralis major muscles are said to be the prime movers in wheelchair propulsion. Other muscles that dominate this phase are external rotators, supraspinatus and infraspinatus muscles, and the serratus anterior muscle which is a scapular protractor (Vanlandewijck & Thompson, 2000; Van Der Woude et al., 2001).

On the other hand, the recovery phase is dominated by active shoulder extensors, posterior deltoid, abductors, medial deltoid and supraspinatus, internal rotator, subscapularis and scapular retractor, medial trapezius (Vanlandewijck, Theisen & Daly, 2001). Interestingly, push phase muscles are also active in the recovery phase for deceleration prior to impact and recovery phase muscles are active at the end of the push phase to prepare for the recovery phase (Vanlandewijck, Theisen & Daly, 2001).

Meanwhile, the rotator cuff muscles are said to be active during the whole propulsion cycle performing their stabilisation duty (Mulroy et al., 1996; Boninger et al., 2002). More importantly, they are active at a high level, close to their maximal capacity (Boninger et al., 2002; Desroches et al., 2010).

Apart from propulsive force, there are compressive forces acting the shoulder joint and torques produced or acting at the shoulder joint (Van Der Woude et al., 2001). Compressive forces acting at the shoulder could reach as high as 2000N. Unfortunately, research has not been able to establish the actual values of joint torques because that would require an invasive technique. However, large net joint torques are reported at the shoulder, indicating large muscle forces

(Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001).

Specific wheelchair basketball dynamics

The specific movement dynamics in WB include intense braking action, the ability to accelerate from standstill, pivoting and quick stops (Vanlandewijck, Theisen & Daly, 2001). Although these dynamics form less than 40% of the WB time, they are all very explosive movements and so require a lot of force from the upper body, specifically the shoulder. Even though they haven't been analysed further, 30 minutes of a WB game consists of about 34% braking action with 240 stops, giving it its high intensity intermittent characteristic according to a study by Seron, Oliveira De Carvalho & Greguo (2019).

According to Vanlandewijck, Theisen & Daly (2001), manoeuvrability of a wheelchair is dependent on seat heat height, shifts in centre of gravity (cog) and resistance from rolling friction of a moving wheelchair. A low seat height and a forward shift in cog allows for faster acceleration from standstill. Therefore, because low point players are unable to actively move their trunk forward, they tend to maximise their speed by choosing a low seat position while high point players can move their trunk forward at will, so they tend to choose a high seat position. This is also because high point players take on scoring duties on the team and low point players take on defensive duties (Vanlandewijck, Theisen & Daly, 2001).

The Role of wheelchair basketball biomechanics

Wheelchair propulsive force is solely created by muscles of the shoulder girdle (Boninger et al., 2002) and moderate propulsive force is created during standard wheelchair propulsion on level surface (Van Der Woude et al., 2001). During WB however, because of the dynamics of the sport like acceleration from stand still and pivoting these forces can get extremely high. This in turn causes high resultant forces on the shoulder (Vanlandewijck, Theisen & Daly, 2001). Veeger & Van del Helm (2007) report that the compression force in the shoulder joint may get as high as 2000N. These extremely high compression forces and the repetitive action of wheelchair propulsion and its dynamics strains the shoulder and this may lead to overuse and pain (Vanlandewijck, Theisen & Daly, 2001; Veeger & van der Helm, 2007; Heyward et al., 2017).

In addition to this, the propulsive forces applied on the hand rim are non-tangential in their direction. This in itself may not be an issue because it ensures that the mechanics of the upper limb do not respond in unusual patterns since the propulsive force is generated during a closed chain movement (Van Der Woude et al., 2001). Figure 2.6 illustrates this.

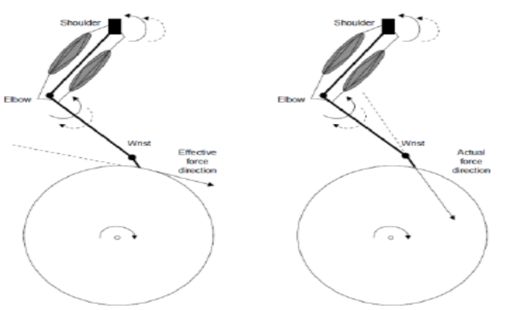

Figure Error! No text of specified style in document.**.7 Effective vs actual direction of propulsive force (Vanlandewijck et al, 2001)**

On the left in figure 2.6 above, with the effective force direction, the elbow would have to move into elbow extension while an elbow flexion moment is required. This would impact the mechanics of the rest of the upper limb joints, including the shoulder (Veeger & van der Helm, 2007). Because wheelchair propulsion is a closed kinetic chain movement though, the actual force direction then tends to be non-tangential as shown on the right side in figure 2.6 (Veeger & van der Helm, 2007). However, during repetitive strokes, Boninger et al (2002) discovered that there are impact strikes due to the non-tangential direction of force applied to the hand rim. These impact strikes may induce trauma to soft tissue structures of the upper limb including the shoulder.

Apart from propulsive force, there are torques being produced at the shoulder during propulsion. These torques can provide an indication of the forces needed at the GH joint during this time. Studies have only been able to calculate net torques over individual muscle torques. Because of the need for stability at the GH joint, net torques may be an underestimation of the total forces since antagonist muscles are active as well. This means that sometimes the torques can cancel each other out, producing a net torque of zero when the forces are not zero.

Among WB players, a dominant external rotation and abduction moment was reported during submaximal wheeling (Vanlandewijck, Theisen & Daly, 2001). However, during acceleration from standstill, forward flexion of the trunk leads to internal rotation of the shoulder, with the external rotators working eccentrically. A situation of repetitive internal rotation position with high external rotator and abduction load is a risk factor for impingement of the supraspinatus muscle (Vanlandewijck, Theisen & Daly, 2001). In addition, high ER compared to IR moments, and high abduction compared to adduction moments are a risk factor for muscle imbalances leading to the subsequent weakness of adductors to abductors and internal rotators to external rotators (Vanlandewijck, Theisen & Daly, 2001; Desroches, Aissaoui & Bourbonnais, 2008; Soo Hoo, 2019).

The throwing shoulder

Overhead activities in people with disabilities have been associated with increased load on the shoulder and therefore increased risk of rotator cuff tears (Akbar et al., 2015). High point players are most likely to be affected by this because they take on shooting duties for the team (Vanlandewijck, Theisen & Daly, 2001; Yildirim, Comert & Ozengin, 2010).

Prevention of shoulder pain in wheelchair basketball

Few studies have discussed ways to prevent shoulder pain in wheelchair basketball players. Strengthening exercises may be useful in the prevention of SP in WB players but a balance must be found between exercising the shoulder and overuse (Heyward et al., 2017). Stretching and range of motion exercises have also been recommended by a few studies (Wilroy & Hibberd, 2018; García-Gómez et al., 2019).

Wilroy and Hibberd (2018) in their study adapted a six-week programme that was previously used for swimmers to improve characteristics associated with SP in college WB players in a pre and post-test study. The programme focused on improving internal and external rotation ranges of motion and the strength of subscapularis, infraspinatus and teres minor, scapular stabilisers and trapezius muscles. Strengthening exercises were conducted using resistance bands with progressive resistance for the first three weeks and then repeated with different number of repetitions the final three weeks. Static stretching was incorporated as part of the program to combat tightness of pectoralis minor muscle (Wilroy & Hibberd, 2018).

A non-randomised clinical trial evaluated a ten-week exercise programme to improve SP and maintain shoulder function (García-Gómez et al., 2019). Unlike Wilroy and Hibberd (2018), this programme included warm up and cool down exercises which have been associated with SP (Lepera, 2010) and have been recommended in prevention of sports injuries (Henke et al., 2017). Like Wilroy and Hibberd however, the programme included strengthening exercises using resistance bands and stretching exercises. This study included strengthening exercises for scapula retractors and depressors, shoulder rotators and adductors, and serratus anterior which is a scapular protractor and stabiliser. Stretching exercises included pectoral muscles and other muscles. This study covered a lot more factors that have been associated with shoulder pain in WB players compared to the study by Wilroy and Hibberd (2018).

Because both exercise programmes were to be conducted at home, the players were given logs where they could fill in the date and exercises conducted. García-Gómez et al (2019) followed this up with reminders through emails and phone. The athletes were also given pictures that demonstrated how each of the exercises were done in both studies. This however does not completely take the chance of the exercises not being conducted appropriately or not being conducted at all.

Internal and external rotation ranges of motion improved by eleven and eight degrees respectively at the end of the six-week exercise programme (Wilroy & Hibberd, 2018) while there was no significant improvement in the ROM in the ten-week programme (García-Gómez et al., 2019). A study conducted on competitive swimmers who also develop tightness of the pectoralis minor suggested considering the use of muscle energy techniques to stretch pectoralis minor. Muscle energy techniques have been proven to increase flexibility more than static stretching (Laudner et al., 2015).

In their study, Wilroy & Hibberd (2018) were not able to assess scapular position before and after intervention due to limitations in posture assessment for wheelchair users even though scapular stabilisers were targeted in the programme. However, the programme had shown to cause improvements in posture of swimmers (Kluemper, Uhl & Hazelrigg, 2006). The study by García-Gómez found that even though SP and strength did not improve after ten weeks of the exercise programme, shoulder function was maintained, and the WB players did not develop SP during competition. Both of these studies have brought about important contributions as far as prevention of SP in WB players.

There was no improvement in muscle strength however (Wilroy & Hibberd, 2018). WB players may undergo intense strength and conditioning programmes with their coaches and trainers that perhaps strengthening using resistance bands may not be adequate (Wilroy & Hibberd, 2018). One such programme is located in the strength and conditioning philosophy document for British WB players where strengthening exercises of intensity as high as five rep max (repetition maximum) are found (Jarvis, 2009).

A study by Burnham et al (1993), reports that shoulder muscles of WB players may be even stronger than able-bodied athletes due to the high loads constantly placed on the shoulder for wheelchair use and basketball. While literature recommends strengthening of shoulder muscles, an emphasis must also be placed on muscle imbalance since that is the known problem as opposed to strength alone. Both studies by Wilroy and Hibberd and García-Gómez et al work on strengthening of shoulder muscles. While Wilroy & Hibberd (2018) had strengthening exercises for scapula thoracic muscles, their programme did not include strengthening of shoulder adductors which are necessary to strengthen considering that abductor/adductor strength imbalance is a big risk factor for SP among WB players. However, García-Gómez et al (2019) made sure to include them in their programme. A holistic programme should be able to carter for all the muscle imbalances.

The strength and conditioning philosophy for Great Britain WB athletes suggests that it may be necessary to work on corrective exercises for posture before proceeding to strengthening and of course maintenance (Jarvis, 2009). Scapula protraction is a prominent feature in WB players (Burnham et al., 1993; Curtis & Black, 1999; García-Gómez et al., 2019) such that it may be necessary for the exercises to target it more and not just as part of a strengthening programme.

Wilroy and Hibberd (2018) adapted an exercise programme that was previously reported to work for competitive swimmers. The pattern of muscle imbalance has been described to be different in WB with shoulder adductors being weaker than abductors compared to swimmers who have weaker abductors than adductors (Burnham et al., 1993). The study however did a pre-test evaluation where they found that the WB players in their study presented with similar physical characteristics with other overhead sports. Their pre-test evaluation however focused on assessment of strength of internal and external rotators of the shoulder and scapula stabilisers as opposed to adductors and abductors of the shoulder.

Literature has reported differences in the mechanisms that may result in SP for WB players with high class and low class IWBF ranks (Curtis & Black, 1999; Yildirim, Comert & Ozengin, 2010; Tsunoda et al., 2016). Mateus and Pillay (2019) in their dissertation suggest that point classification of WB players be considered when addressing issues concerning WB. Player position and role in the team have also been suggested to be considered when thinking about injury prevention for WB players (Lee, McKay & Gutierrez, 2020). Yet the studies addressing

prevention of shoulder pain above conducted the same exercises for all the participants of the studies regardless of their classification and role in the team or playing position.

Christiana (2019) in her study on SP and its risk factors in WB players in Johannesburg identified IR ROM and instability as risk factors associated with SP in Johannesburg. Instability has not been addressed directly in the studies that have looked at prevention of shoulder pain among wheelchair basketball players. They partially address it by strengthening the rotator cuff muscles but large shoulder adductors like latissimus dorsi and pectoralis major have been known to assist in stabilisation of the shoulder by opposing upward pull of the humeral head by the deltoid muscle (Veeger & van der Helm, 2007; Lugo, Kung & Ma, 2008).

Wheelchair basketball versus other sports

According to Aytar et al (2015) shoulder pain and scapular dyskinesis was worse in WB compared to amputee soccer and disabled tennis. While SP and abnormal scapular positioning are associated with repetitive hand rim propulsion and overhead activities, in disabled tennis it was associated with repetitive use of the upper limbs at and above shoulder level, trunk movements and shortening of neck and anterior muscles of the shoulder girdle (Aytar et al., 2015). For amputee soccer SP was associated with crutch usage.

In overhead sports, while SP is also prevalent, the pattern of muscle imbalance varies. Among WB players, there is stronger abductors compared to adductors while the opposite is true in overhead sports (Burnham et al., 1993). Wilroy & Hibberd (2019) however reported swimmers presenting with the same functional deficits as WB players. However, the study only discussed scapular dyskinesis, GHJ ROM and weakness of shoulder muscles in general.

Review of research articles included in review

The articles included in this literature review on prevalence and risk factors have all been cross sectional studies. Cross sectional study design is a good methodology for prevalence studies (Lepera, 2010; Robinson, 2011). The studies also addressed issues of pain intensity and classification of players which is good. They also used instruments with high validity and reliability with clearly presented outcomes. For the studies in South Africa, the instruments were even adapted to suit the conditions locally. Most of the studies had a lot of items on the STROBE checklist well covered making them high quality studies even though observational studies are not the highest level of evidence on the evidence pyramid (Murad et al., 2016).

Some of the studies had big samples (Curtis, burnham) while some of the studies had small samples. The studies conducted in South Africa especially had small samples with the maximum a little below fifty participants (Lepera, 2010; Christiana, 2019; Mateus & Pillay, 2019). These small sample sizes may not be representative of the country.

Studies on prevention of SP are few generally (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). These studies focused on a lot of factors associated with SP in WB. García-Gómez et al (2019) even conducted her study in multiple stages involving developing an exercise programme that was unique and then validated through expert opinion in a Delphi study which they then went on to evaluate (García-Gómez et al., 2017). The studies were non-randomised trials which is less preferred because of issues of bias. When conducted well for topics that have scarce information, non-randomised trials can still be considered high level of evidence (Murad et al., 2016).

Similarly, the biomechanical studies found were mostly non-randomised experimental studies. Some of these studies were conducted well while others had smaller sample sizes and had limitations with their instruments. In this regard, the quality of evidence was variable. Review articles found were mostly non-systematic with one critically appraised topic study.

Conclusion

This chapter discussed shoulder pain and its prevention among wheelchair basketball players.

There has been a lot of research on SP in WB especially in the epidemiology of it. Few studies have been conducted on the prevention of SP in WB players and in my knowledge, none taking into account classification of the players and none in South Africa. This study will add to much needed literature in prevention of Shoulder pain in wheelchair basketball.

Methods

This study is a mixed methods study that began with a scoping review followed by a modified Delphi study. For this reason, this chapter is presented in two parts following the study process. The first part will present the methodology for the scoping review and the second part will present the Delphi study methodology.

1.8 Part one: scoping review methods

Aim

A scoping review was conducted to map out the range of to map the range of preventive strategies for shoulder pain or injury in wheelchair basketball and wheelchair sports.

Study design

An exploratory study was conducted using a scoping review. The review utilised the Arksey and O'Malley framework (Arksey & O'Malley, 2005) and also incorporated the Joanna Briggs Institute (JBI) methodology of scoping reviews (Pham et al., 2014; Tricco et al., 2016). The steps are outlined below.

Identifying research question

In the first step of the scoping review, a research question was defined by the researcher, using the Population Concept Context (PCC) framework (Tricco et al., 2016) as follows: "what exercises are known in literature to prevent shoulder pain among WB players?"

The PCC framework is a method recommended by JBI which is used to define the specific elements of a research question for a scoping review and informs the inclusion criteria (Peters et al., 2015). It clearly states that the research title/question should be brief but comprehensive enough to reflect the population, concept and context of the review as these inform the inclusion and exclusion criteria (Peters et al., 2015).

For this scoping review, the study population are all WB players or wheelchair sports athletes, regardless of sex, gender, age, level of play, classification, etc., because they all could be at risk for developing shoulder pain.

The main concept being examined in this review are exercise-based prevention strategies for shoulder pain in WB or wheelchair sports.

Finally, to map out the range of evidence available, the context of the study was studies across the world and not just limited to South Africa. The review would also consider all prevention programmes whether home-based or not.

Identifying and selecting relevant studies

Three main databases were searched including PubMed, Scopus and EbscoHost, by the researcher and a research assistant as recommended by JBI protocol for conducting a scoping review (Tricco et al., 2016). CINAHL, Medline (Complete) and Sport Discus were included in the EbscoHost search. Search terms used were “Shoulder pain” OR “shoulder injury” AND “wheelchair basketball” OR “wheelchair sport” AND “prevention” OR “treatment” OR “program” OR “exercise”. The search strategy (Appendix I) was developed with the assistance of an experienced Librarian, with an example for PubMed provided in the figure below. The rest of the databases followed the same structure.

Database: Medline via PubMed
Restriction: English Language
Terms were searched for in “Textword and MeSH”, where possible
Search 1: ("shoulder pain"[Text Word] OR "shoulder injury"[Text Word]) AND "wheelchair basketball"[Text Word] AND ("prevention"[Text Word] OR "intervention"[Text Word] OR "program*"[Text Word])
Retrieved: 4 articles
Search 2: ((("shoulder pain"[Text Word] OR "shoulder injury"[Text Word] OR "shoulder impingement"[Text Word] OR "rotator cuff tear"[Text Word]) AND "wheelchair basketball"[Text Word]) OR "overhead sport"[Text Word]) AND ("prevention"[Text Word] OR "intervention"[Text Word] OR "program*"[Text Word])
Retrieved: 12 articles
Search 3: ("shoulder pain"[Text Word] OR "shoulder injury"[Text Word] OR "shoulder joint/injuries"[MeSH Major Topic]) AND "wheelchair basketball"[Text Word] AND ("prevention"[Text Word] OR "intervention"[Text Word] OR "program*"[Text Word])
Retrieved: 4 articles

Table Error! No text of specified style in document.**.1 Search strategy**

Titles and abstracts were screened followed by a review of full text articles. Reference lists were then scanned for the possibility of identifying new articles. This was conducted by the researcher and research assistant independently and then discussed in a briefing meeting.

Only articles published in English were included to save time and translation costs. Studies that recommended or discussed a specific type of exercise were included in keeping with the aim of the review. Studies that discussed prevention of SP using other strategies except exercises were excluded as they were not answering the question of the review. In addition to this, studies that addressed exercise-based prevention strategies in regular overhead sports were excluded because the pattern of muscle imbalance/weakness in overhead sports is slightly different compared to WB. Finally, studies that discussed shoulder pain prevention in paraplegics that did not participate in any sports were also excluded.

Data Charting

After relevant studies were selected, information including the study characteristics and the intervention or exercise program was collected and summarised in a data chart.

Collating, summarising and reporting the results

Exercises identified from the outcome of the scoping review were categorised into strengthening, mobility, stretching and other exercises (García-Gómez et al., 2017). Using the Frequency, Intensity, Time, Type (FITT) principle of exercise prescription (Riebe et al., 2018), the researcher then modified some of the exercises from the recommendations and combined them with a few developed ones to form an exercise program for the prevention of shoulder pain among WB players. This program was then carried over for expert opinion in the next step of the study using a Delphi technique. The scoping review took a period of six weeks in total.

Part two: Delphi methods

This section is discussing the methodology used in the Delphi study, the second phase of this mixed methods study.

Study design

A consensus development study using a modified Delphi study was conducted in three rounds.

1.9 Study setting

This study took place entirely online, with emails sent for communication with participants and questionnaires completed via RedCap.

1.10 Participants

1.10.1 Source of participants

Participants included in this study were selected from recommendations made by other professionals who were aware of their suitability for the study and their involvement in sports. Then the recommended members were sent an invitation to participate in the study through email. The email also included an information sheet (*Appendix II*) explaining the study procedure and purpose, a link for first round questionnaire (*Appendix III*) to be completed via RedCap and a summary of the scoping review findings. A written consent form (*Appendix IV*) formed the first part of the questionnaire. Participants were only allowed to proceed with the rest of the questionnaire upon providing written consent and their signature.

1.10.2 Sample size

According to Grime and Wright (2016), there is no recommended standard of calculating the number of experts that form a Delphi panel even though a sample of 5-20 panel members is recommended. This study comprised of six Delphi panel members.

1.10.3 Sample selection

Convenience sampling method was used to recruit experts for this study. In total 14 emails were sent out to potential participants inviting them to participate in the study. This phase took three weeks, allowing the potential participants to make a decision.

1.10.3.1 Inclusion criteria

The panel included physiotherapists, biokineticitists and sports scientists that are

i. Male and female with a minimum of a bachelor's degree in their respective field.
ii. Currently involved in wheelchair basketball, basketball, and overhead sports for two years or more by the time of the research.
iii. Registered with HPCSA or their respective council

1.10.3.2 Exclusion criteria

i. Not practicing in Southern Africa

1.11 Instrumentation and outcome measures

1.11.1 Round one questionnaire

Following completion of the scoping review, exercises identified were compiled into a questionnaire for the first round (*Appendix III*) using FITT (Frequency, Intensity, Type and

6

Time) format of exercise prescription (Riebe et al., 2018) and rated using a five-point Likert scale from strongly disagree to strongly agree. The third option, modify, had a space allocated for participants to state their recommended modification(s) to the particular exercise.

This questionnaire was formed using the draft from Keeney, Hasson and Mckenna (2011) and reviewed by a professional Physiotherapist and lecturer before it was sent to three participants in a pilot study. Once completed, the questionnaire was modified by correcting few misspelt words and including a summary of the findings from the scoping review and the purpose of the study as an introduction.

The exercises in the questionnaire were categorised into four main sections including warm-up, strengthening exercises, scapular stabilisers activation and cool-down. Each exercise consisted of its dosage following the FITT format of exercise prescription (Riebe et al., 2018) and its progression throughout the length of the program which was set for nine weeks.

The warm-up section was further subdivided into two phases, one and two. The first phase contained four exercises of active movements of the shoulder and the goal was to encourage mobility and flexibility of the shoulder. The goal of the second phase of warm-up was to encourage correct movement patterns and it consisted of three functional exercises.

The second section of the exercise program was made up of seven strengthening exercises of the shoulder, including external rotation (ER) and internal rotation (IR), serratus anterior, biceps curls, scapular depression and abduction, scapular retraction, and shoulder adduction strength. The third section consisted of two exercises for activating scapular stabilisers and the final section, cool-down, was made up of four stretching exercises for the pectoralis major and minor muscles, upper trapezius and levator scapulae, posterior capsule, and internal and external rotators of the shoulder.

1.11.2 Round two questionnaire

Round two questionnaire (*Appendix V*) was compiled from exercises that reached a median score of three but did not reach a consensus agreement of 80% from the first round. Recommendations made and a summary of the results from the first round were added to the questionnaire. The figure below shows the format for the questionnaire in the second round.

Exercise	Feedback Summary	Your Previous Response	Recommended Modification(s)

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Figure Error! No text of specified style in document..**8 Excerpt of second-round questionnaire**

1.12 Procedure

1.12.1 Pilot study

Exercises from the scoping review were compiled into a questionnaire which was then reviewed and revised by the researcher and the supervisor before it was sent out to three physiotherapists. 18 The aim of the pilot study was to ensure that the questions on the questionnaire were clear and concise and to check for misspelt words and make corrections. In addition to this, the pilot study was conducted to refine the questionnaire if necessary and to test for data analysis techniques. The pilot study also allows the researcher to check for ambiguities (Skinner et al., 2015).

Once the three participants responded to the questionnaire, a summary of their feedback was made. One participant on commenting on internal and external rotation of the shoulder procedure in the warm-up said, "What is meant by stabilised to body by a resistance band? However I understand this involves IR/ER at the shoulder." Also, three misspelt words were identified and corrected. Following this, the questionnaire was modified by correcting the misspelt words clarifying the procedure.

Once this was completed, 53 one of the pilot study participants was included in the main study because they qualified to participate in the main study.

First round

Upon completion of the scoping review, a 9-week exercise program was compiled, informed from literature discovered in the scoping review, grey literature (Jarvis, 2009), and the researcher's 3-year experience working with wheelchair users. This program was arranged into four sections including warm-up, strengthening exercises, scapula stabilisers activation and cool down phases. Each exercise had a description of the position it would be conducted in, the procedure of the way the exercise should be conducted, a prescription using the FITT principle and the way the exercise would be progressed. A brief summary of SP among WB players and the findings from the scoping review was presented and together with the exercise program formed the first-round questionnaire.

Expert panel members were then contacted via email and were asked to vote for each exercise 21 using a 5-point Likert scale from strongly disagree to strongly agree. An information sheet explaining the study process was provided in the email to all the potential participants. 20 Upon provision of consent, panel members were allowed to proceed and rate each exercise on a 5-point Likert scale on from strongly disagree to strongly agree. If they chose the third option, modify, they were allowed to suggest modifications to the exercise they thought needed modifying.

The voting process took three weeks even though originally planned for two weeks due to the low response rates in the first round.

Second round

All exercises that had a median score of ≥3 but did not reach a consensus agreement of 80% during the first round, were carried over to the second round. In addition to this, a column with quantitative and qualitative feedback from the first round was provided on each exercise. Another column for their previous response was also provided. To provide the experts with comprehensive feedback, common themes per phase were provided in the questionnaire and a separate summary sheet of descriptive statistics (*Appendix VI*) was provided as well.

Panel members were then provided with three options: to maintain their previous response, or to change their response for the same exercise as it was in the first round, or to select modifications to be made from the recommendations. The questionnaire would then proceed depending on their choice. If the member chose to maintain their previous response, they were allowed to proceed to the next exercise. If they chose to change their response, a Likert scale as in the first round would appear. The third option, which was to modify, was changed to neutral in this case. Lastly, if they chose to select modifications, recommended modifications would appear. Members were allowed to select one or more modifications depending on whether the modifications would go together or not. For example, if two modifications were both recommending increasing dosage but with different numbers of repetitions, then participants were only allowed to select only one of them. On the other hand, if the modifications were addressing different aspects of the exercise, then participants were allowed to select as many modifications as they deemed fit.

Third round

An hour-long consensus meeting was conducted virtually using zoom. Participants were sent links for the meeting apriori with instructions to log in using their participant numbers which were provided to them in the second round. They were also instructed to turn off their videos. To ascertain anonymity, participants were all put in the waiting room before the start of the meeting so that the facilitator would change their names to participant numbers in the case that the name still appeared. Furthermore, the meeting was conducted in focus modification which ensures that members of the meeting are unable to see each other's video even if a participant turned on their video by mistake.

The aim and procedure of the meeting were explained to panel members in the beginning of the meeting using a PowerPoint presentation (*Appendix VII*). Then panel members were asked for permission to record the meeting for purposes of the research. Once permission was provided, the meeting was recorded, and the researcher only facilitated the discussion to ensure that the aim of the meeting was being followed and that all panel members were given a chance to communicate. A summary form (*Appendix VIII*) of the second-round feedback which was provided to the panel members before the meeting was used to provide visual input of the discussion.

Defining consensus

26 A consensus of 51% to 85% is generally acceptable (Keeney, Hason and Mckenna, 2011). According to a systematic review conducted by (Diamond et al., 2014), a consensus of 80% was more common. Therefore, for the purpose of this study, consensus was determined by an agreement rate of 80% or more.

Enhancing response rates

Prior to commencement of the study, experts were made aware of the study process through an information sheet (Keeney, Hasson & Mckenna, 2011; Toma & Picioreanu, 2016) and a sense of ownership was encouraged (Keeney, Hasson & Mckenna, 2011) by allowing experts to make modifications to exercises in the first round.

Communication was maintained by sending of appreciation messages upon completion of a questionnaire and reminders before completion. Responses were being tracked on RedCap and reminders were sent via email to participants that had not yet completed the questionnaires. The first reminder was sent five days after the questionnaire was sent. Then a second reminder would be sent after another five days. For participants that were still yet to respond, a phone call would be made to remind them.

Lastly, rounds were kept short requiring fifteen to thirty minutes to complete a questionnaire and feedback from the first and second rounds was sent to all the panel members.

Managing dropouts

Dropouts prior to the first round were considered not to affect the study and the expert was replaced (Toma & Picioreanu, 2016). Following the first round, one expert was loss to follow-up and so five experts participated in the second round. In the third round, one expert was also loss to follow-up while one expert had an emergency on the day of the meeting. The final round was completed by three members of the panel. These dropouts have been considered to have affected consensus and reported in the discussion and results (Toma & Picioreanu, 2016).

1.13 Ethical considerations

The study was approved (Appendix IX) by the Human Research Ethics Committee (HREC) at the University of Witwatersrand. Privacy and anonymity were maintained throughout the Delphi process. Participants were referred to using codes in the second and third rounds, when providing feedback and during the virtual meeting. Participants were asked to change their participant id to their participant number on zoom for the purpose of this project.

Informed consent sheets were only viewed by the researcher. To maintain anonymity of the participants, only the researcher had access to the demographic and consent information of the participants. The rest of the research team were only given access to the questionnaires without the demographic and consent information.

1.14 Data analyses

Data was analysed using SPSS version 18.0 (SPSS Inc., Chicago, IL) and Microsoft excel. Descriptive statistics were analysed and compiled. Frequencies were calculated for each exercise to check for consensus. The table below provides a summary of the descriptive analysis.

Objective	Expected Outcome	Type of Variable	Analysis
To obtain experts' consensus on exercises to be included in the prevention programme.	Likert scale variables Strongly disagree, Disagree, Modify, Agree, strongly agree	Ordinal	Descriptive statistics: Frequencies (%) Median Interquartile range
To conduct a scoping literature review on current preventive strategies for shoulder pain in overhead sports	Authors, year of study, type of study, exercise-based intervention and recommendation	Categorical	Descriptive statistics: Frequencies (counts/numbers)

Table Error! No text of specified style in document.**.2 Descriptive statistics**

Recommended modifications were analysed qualitatively using content analysis. Statements to be analysed came from recommended modifications to exercises if the participant chose to modify the exercise. Content analysis was done with a directed approach, from previous literature on the topic gathered during the scoping review and a narrative review (Neuendorf, 2019) Data analysis was conducted by the researcher and a research assistant for trustworthiness.

In the first step, familiarisation of data was done by reading and re-reading data multiple times. On the third attempt, short notes were jotted down during the process of reading the data. Notes were written for every exercise, describing how every participant responded to an exercise. Then the general impression for each section of the program, warm-up phases one and two, strengthening exercises, scapular stabilisers activation, and cool down, for each participant was written down.

Following familiarisation, all recommended modifications per exercise were written down on a separate sheet of paper without developing initial codes. Then each modification was broken down into simple statements, keeping the wording of the writer the same. See figure below for further details.

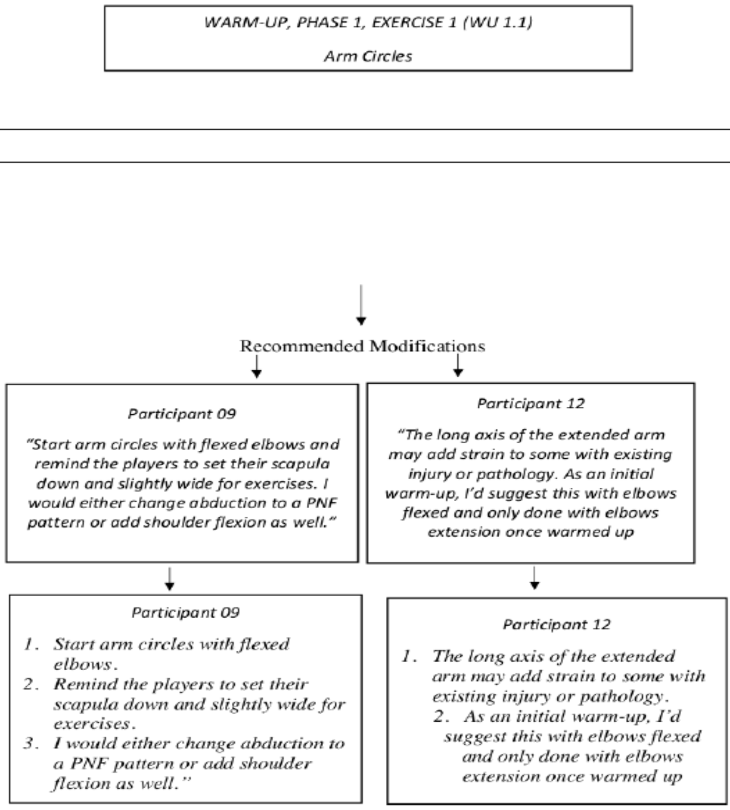

Figure Error! No text of specified style in document..**9 Excerpt from qualitative data analysis**

After breaking down the statements, action words were highlighted, with common actions highlighted in the same colour. Upon completion of this, initial codes were developed, derived from participant's original words and some additional codes that were not in the original words of the participants. Then initial codes were developed with reference from literature included in the scoping review. Some codes were kept in the original words of the participants while others were not. Following initial coding, a debriefing meeting was conducted to encourage trustworthiness by removing researcher bias. Then, the codes were grouped into four categories based on the four dosage parameters of the FITT principle and one miscellaneous category for other codes that did not fit into any of the four categories. See table below.

Exercise	

	Altering the procedure of an exercise	Altering the type of exercise	Altering dosage of an exercise	Changing sections
	Position of exercise	**Strength endurance** **Pure strength** **Activation**	**Intensity** **Frequency** **Repetitions**	**New section** **Warm-up**

Table Error! No text of specified style in document..**3 Data analysis matrix**

On reporting to the panel members during provision of feedback, recommended modifications were reported in almost exact wording of the participant who recommended them. Abbreviations were expanded for example a participant used HBB for Hands behind the back. This abbreviation was reported as Hands behind the back during the feedback process. Modifications that were similar but had different wording were reported using one of the recommendations' words or were combined using developed codes and categories, keeping the meaning the same.

Conclusion of methodology

This chapter outlines the methods used in this study. The study design, aims, and the way data has been analysed has been discussed in this chapter. Ethical considerations have also been outlined clearly.

Results

Introduction

This chapter outlines the results for this study. The articles included in the scoping review, consensus and other descriptive statistics in the first to the third rounds will be presented.

Scoping review

Description of studies

About 127 articles were identified from the initial search. After, removal of duplicates, 117 articles went through the screening process. Eventually, only five articles met the inclusion criteria. The table below is the evaluation flow chart detailing the research process.

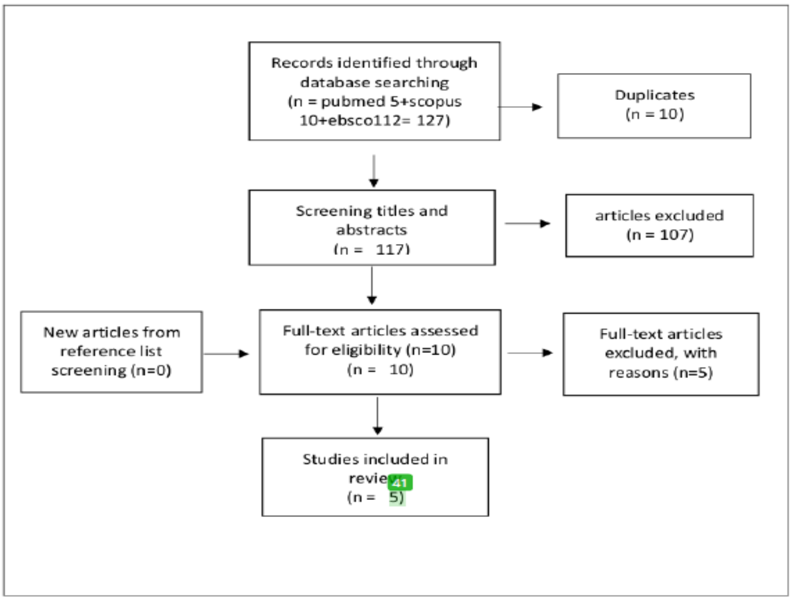

Figure Error! No text of specified style in document..**10 Flow chart for scoping review process**

Of the five articles, only two were experimental studies and the rest were review articles. In the two experimental studies (Wilroy & Hibberd, 2018; García-Gómez et al., 2019), home-based exercise programs were presented and implemented on WB players. Two of the review articles presented a rehabilitation protocol and a strength and conditioning program that may be applied in the preventing shoulder pain (Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020). Curtis (1997) just presented recommendations of exercises that would be useful in preventing SP in wheelchair sports. The characteristics of the included studies and their recommended exercises are presented in the table below.

Title/ author(s)/ year/study design	**Program type**	**Recommended exercise**			
		Frequency	**Intensity**	**Type**	**Time**
Prevention and Treatment of Wheelchair Athletic In juries/ Kathleen A. Curtis/ 1997/ review article	N/A	Not indicated	Not indicated	Strengthening of posterior shoulder, including posterior deltoid, latissimus dorsi, rotator cuff, and middle and lower trapezius muscles	Not indicated
Evaluation of a Shoulder Injury Prevention Program In Wheelchair Basketball/ Jereme Wilroy and Elizabeth Hibberd/ 2019/ Pretest and posttest/	Home-based	3 sets, 10 reps, week 1 and 4 3 sets, 15 reps, week 2 and 5 3 sets, 20 reps, week 3 and 6	Used 2 levels of resistance bands on the participants' current ability, with first band used in the first 3 weeks then progressed to more difficult band next 3	Strengthening exercises including scapular retraction, ER, and shoulder flexion for lower trapezius	6 weeks, 3 times/week
		3 reps, 20 seconds	N/A	IR stretch	
Effect of a Home-based Exercise Program on Shoulder Pain and Range of Motion in Elite Wheelchair Basketball Players: A Non-Randomized Controlled Trial/ García-Gómez et al/ 2019	Home-based	8 reps		Warm-up made up of 4 active movements of the GHJ	12 weeks,
		3 sets, 10 repetitions, with 45s rest between sets, and 10-15s rest between exercises	Variable resistance therapeutic band	strengthening exercises for serratus anterior, scapula retraction & depression, and shoulder rotation & adduction (rest between sets).	
		5 reps, 20 s hold, 15 s rest		5 stretching exercises for trapezius superior, medial and inferior portion, posterior	

				posterior shoulder, pectoral and biceps brachial muscles	
27 Shoulder Rehabilitation Protocol and Equipment Fit Recommendations for the Wheelchair Sport Athlete With Shoulder Pain/ Riley and	N/A	60s hold, 3 reps		Acute phase 4 stretching exercises of the pectoralis minor, posterior shoulder, latissimus dorsi and	

Title/ author(s)/ year/study design	Program type	Recommended exercise			
		Frequency	Intensity	Type	Time
Callahan/ 2019/ review article		10 reps, 3 sets, progressed to 20 reps, 3 sets, further progressed to 30 reps, 3 sets	Variable resistance using weights	levator scapulae 5 strengthening exercises of rotator cuff and scapula muscles	
		10 reps, 3 sets, progressed to 20 reps, 3 sets, further progressed to 30 reps, 3 sets	Variable resistance using weights	Maintenance phase 9 strengthening exercises of the rotator cuff, scapula muscles and other shoulder muscles like biceps brachii and latissimus dorsi	
		10 reps, 3 sets	Variable resistance	Performance phase All stretches from acute phase 5 strengthening exercises of the scapula muscles and other shoulder muscles	
A Shoulder Strength Program for Wheelchair	N/A	Variable for strength, hypertrophy and endurance	Not specific, depending on goal	Upper body stretches including shoulder,	Not indicated

Title/ author(s)/ year/study design	Program type	Recommended exercise			
		Frequency	Intensity	Type	Time
Basketball Players/ Lee et al/ 2020/ review article				chest and neck stretches Strengthening exercises of the chest, back & abs, and shoulders & arms	

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Table Error! No text of specified style in document.**.4 Description of included studies**

Study outcomes

All the studies support the inclusion of strengthening exercises of muscles of the shoulder complex, including the rotator cuff, and 80% of the studies include stretching for flexibility.

Warm-up

Three articles recommend the inclusion of warm-up for mobility and flexibility before proceeding to strengthening exercises (Curtis, 1997; García-Gómez et al., 2019; Lee, McKay & Gutierrez, 2020). Riley & Callahan (2019) began their acute and performance phases of their exercise protocol with stretching before strengthening exercises are done. They are not clear however whether the stretching could be considered as a form of warm-up or just part of the whole protocol. Only Wilroy & Hibberd (2018) do not mention warm-up in their study even though stretching was conducted after strengthening exercises.

Strengthening exercises

All the studies support the inclusion of strengthening exercises of muscles of the shoulder complex including the rotator cuff. However, the actual muscles included in the strengthening programmes varied among studies. While none of the studies specifically spoke to muscle endurance, two of the studies (Wilroy & Hibberd, 2018; Riley & Callahan, 2019) included dosage progressions of more than 15 reps. Lee, McKay & Gutierrez (2020) just provides dosages for strength, power, endurance and hypertrophy and leaves it to the discretion of the one prescribing.

Stretching or cool down

While all the studies recommend that stretching exercises should be done, some studies recommend it done before strengthening exercises (Curtis, 1997; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020) while others believe it should be done after strengthening exercises (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). The stretches included in the various studies varied, with pectoral muscles and posterior shoulder stretches common in all the studies except Curtis (1997).

1.15 Delphi Results

Participant characteristics

The panel included five physiotherapists, with at least a bachelor's degree in physiotherapy, and one Biokinecitist with a Master of Science degree in sports science in the first round. The minimum years of experience related to basketball, wheelchair basketball or overhead sports was five years and a maximum of 20 years' experience. Below is a summary of participant characteristics.

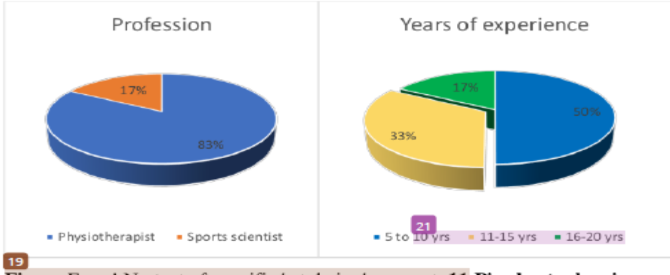

Figure Error! No text of specified style in document.**.11 Pie charts showing participant characteristics**

Five participants participated in the second round with one loss to follow up. Four participants confirmed to participate in this round. one was loss to follow-up while one had an emergency during the time of the meeting. See figure below.

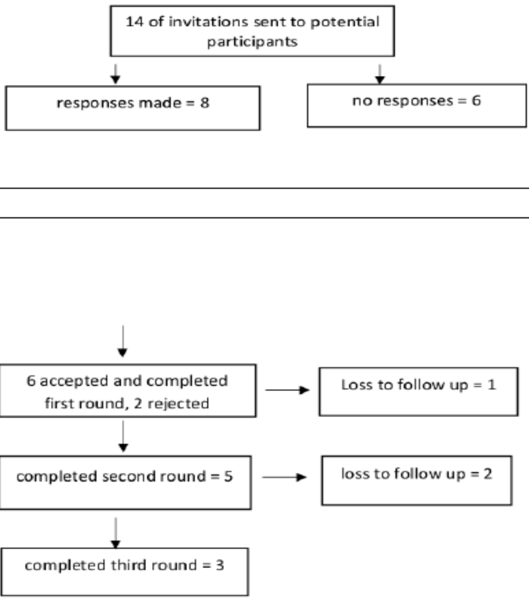

Figure Error! No text of specified style in document.**.12 Participation of panel members in the 3 Delphi rounds**

Quantitative summary

In the first round, nine out of 23 (39.1%) exercises of the prevention program reached consensus. The rest did not but had a median score of three and so were carried over to the second round. No exercise was excluded. No exercise reached consensus in the second round and in the third round 75% of the recommended modifications had a 100% agreement from panel members in the meeting. These modified exercises and all the exercises that reached consensus in the first round were all included in the final prevention program (*Appendix X*).

Warm-up

The warm-up section was made of seven exercises organised in two phases. The first phase was made up of four active range of motion exercises for mobility and flexibility of the shoulder and the second phase consisted of three functional exercises to encourage correct movement patterns.

Consensus

In the first and second rounds, all the exercises in the warm-up phase did not reach a consensus agreement of 80% as illustrated by figures 4.4 and 4.5 respectively. However, all of them had a median score of ≥3 (see figure 4.6) below.

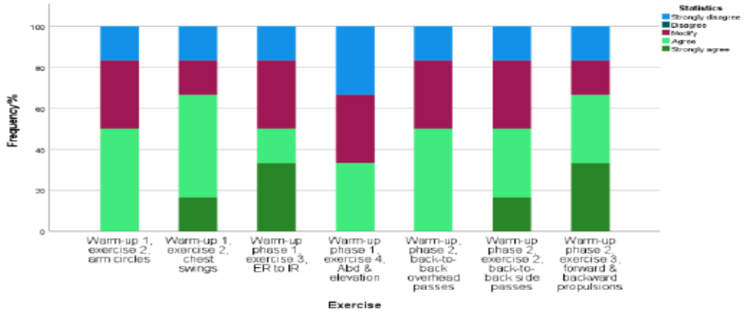

Figure Error! No text of specified style in document..13 **Frequency of responses for warm-up exercises in the first round**

In figure 4.4, the percentage of agree and strongly agree responses are represented in different shades of green, with the highest percentage of just over 60% for chest swings and forward and backward propulsions.

In the second round, the frequency of modify responses increased and the percentage of agree responses generally reduced, with the highest agreement rate presented in green, being 40% (figure 4.5). The frequency in the second round was calculated with the drop out of one participant taken into account.

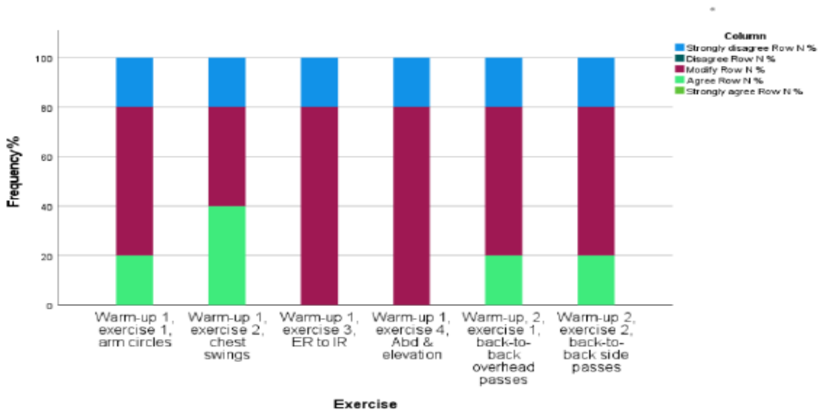

Figure Error! No text of specified style in document..14 **Frequency of responses in the second round**

In the second round, participants selected different modifications recommended from the first round. Some participants however chose to maintain the exercises the way they were originally, even though the frequency for this had reduced compared to the first round. A descriptive summary of the selected modifications is provided in table 4.2 below.

Exercise	**Recommended modifications**	**Descriptive summary**
Arm circles	1- start with elbows flexed, remind players to set scapula down and slightly wide. Proceed to arm circles with extended elbows once warmed up 2- change abduction to PNF pattern	50% of the participants chose to modify with, 16.7% agreeing to modification 1 and, 33% agreeing to modification 2. ***One of these participants suggested to include both D1 and D2, flexion and extension patterns***, while ***the other one***

		went with D2 extension pattern.
Chest swings	1- the scapular needs to depress as well for lower fibers of trapezius	33% participants chose to modify and both of them agreed with the recommended modification
ER to IR	1- increase dose to 1 minute 2- include detailed description of how scapula will be stabilised	67% participants chose to modify with, 33% agreeing to modification 1 and,

		all 67% of the participants agreeing to modification 2
Abduction and elevation	1- focus on scapula position during exercise 2- shorten axis by flexing elbow 3- if elbow extension is maintained, add palms facing up to encourage external rotation beyond 90 degrees	67% of the participants chose to modify with, 16.67% agreeing to modification 1, emphasizing use of a picture to help players to visualise scapular position, 50% agreeing to modification 2 and, 33% agreeing to modification 3
Back-to-back overhead passes	1- the athletes should be placed facing each other 2- move exercise to new section, skills development section after cool-down 3- include trunk balance and scapular position	50% of the participants chose to modify with, all of them agreeing to modifications 1 & 2 and, 33% agreeing to modification 3
Back-to-back side passes	1- create and move exercise to skills development section 2- players should have wheelchairs side-by-side 3- include trunk balance and scapular position	50% of the participants chose to modify with, all of them agreeing to modifications 1 and 2 and, 33% agreeing to modification 3

Table Error! No text of specified style in document..5 descriptive summary of round 2 recommended modifications

Finally, consensus was affected by low participation in the third round, however there was 100% agreement for the participants in the meeting on some items. In the third round, for each exercise in the warm-up section, there was a modification or modifications that had 100% agreement among the participants present in the consensus meeting. Modification(s) or exercises that did not have 100% agreement were excluded in the final program.

Strengthening exercises

Consensus

Out of the nine strengthening exercises, three (33.3%) exercises including serratus anterior strength, chest press and lat pull up, reached a consensus agreement of ≥80% in the first round and so were excluded from the second round. The graph (figure 4.6) below provides a descriptive summary of how panel members rated the strengthening exercises. The percentage of participants that voted for each option (strongly disagree, disagree, modify, agree, and strongly agree) is shown, with agreement rate presented in different shades of green.

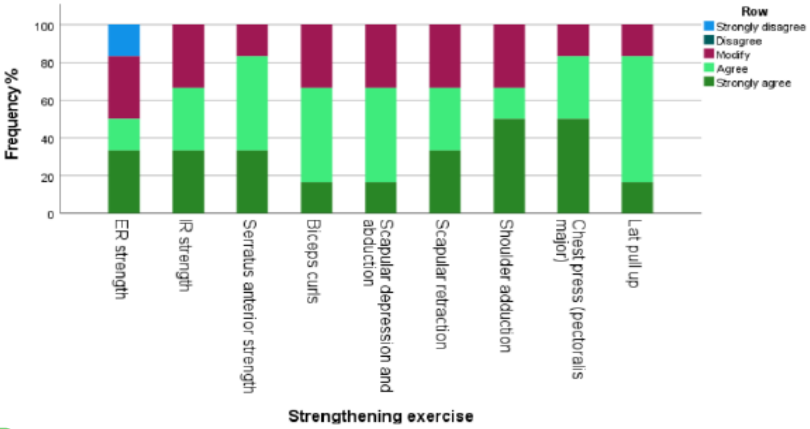

Figure Error! No text of specified style in document..15 Frequency of agreement for each strengthening exercise in the first round

The trend continued in the section for strengthening exercises just like in the warm-up section. The frequency of modify responses slightly increased, with participants selecting different modifications recommended from the first round. Unlike the first round however, no participant disagreed with any of the strengthening exercises in the second round. Even with that however, none of the six strengthening exercises reached consensus in the second round. Below is a summary of the frequency of responses to the strengthening exercises in the second round.

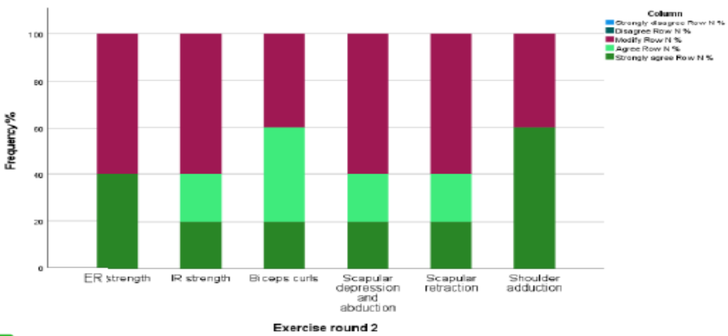

Figure Error! No text of specified style in document..16 Frequency of responses for strengthening exercises in the second round

In the third round, consensus was affected by low participation, however 100% consensus for the participants in the meeting on some modified exercises which were added to the shoulder pain prevention program.

Scapular stabilisers activation

Two out of three (66.7%) exercises of activating scapular stabilisers, the serratus punch and lower trapezius activation, reached a consensus of ≥80% agreement clearly indicated in green the graph below. Only Y's t's & w's exercise did not reach consensus, with an agreement of 67%. The serratus punch and lower trapezius activation were excluded from the second round and were automatically part of the Shoulder pain Prevention Program in w/c basketball (SPP-WB). The chart below shows a summary of the number of panel members voted for each category (strongly disagree, disagree, modify, agree, and strongly agree) for each exercise.

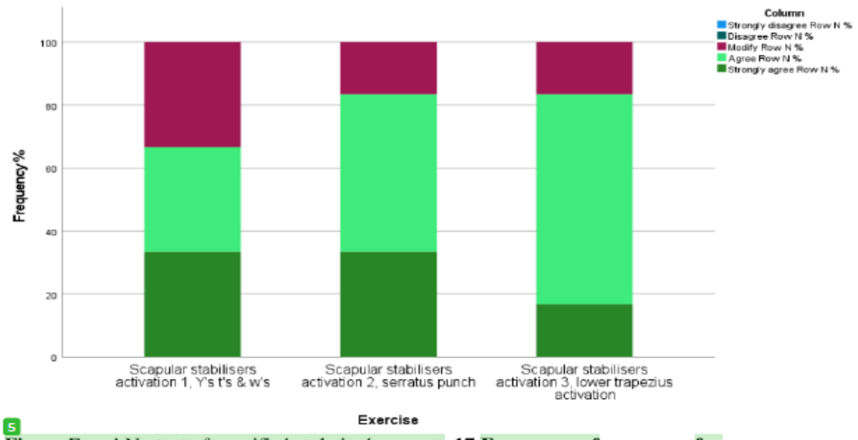

Figure Error! No text of specified style in document.**.17 Frequency of responses for scapular stabiliser activation exercises**

At least half of the participants agreed with Y's t's & w's exercise, with a median score of four. This exercise was therefore included in the second round of the Delphi, with its recommended modifications presented. There was also less variation in the responses indicated by an interquartile range of one.

In the second round, the y's, t's, w's still had an agreement rate of <80%. However, in the third round, it was accepted by all the participants in the final round as it was, with the note to take care of participants that may find it challenging to go into prone position and advise therapists or qualified user of program to adjust as appropriate in those instances.

Cool down

All four stretches in the cool down section reached a consensus of ≥80% agreement, with posterior capsule stretch having 100% agreement, in the first round. All four exercises were therefore excluded from the second round and were automatically included in the SPP-WB. There was also little variation, with only one participant opting to modify the other three exercises with interquartile ranges from 0.25 to 0.45. Below is a chart presenting the frequency of agreement. The group's median score is presented in figure 4.9 below.

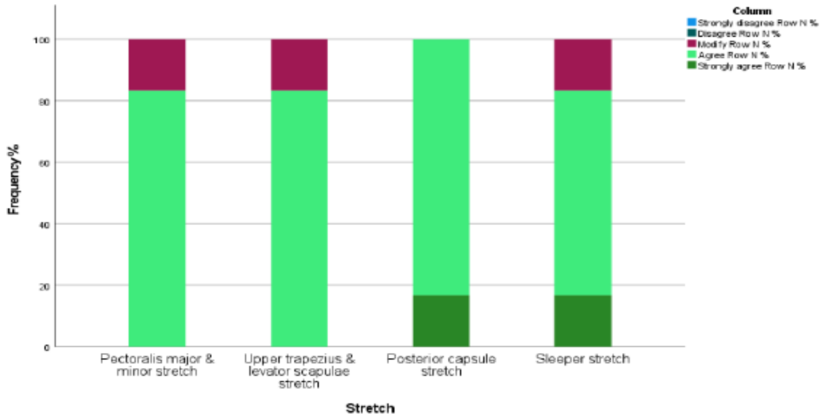

Figure Error! No text of specified style in document.**.18 All cool-down exercises having >80% agreement**

Qualitative results

According to the data analysis, there was a high tendency of answers regarding altering the procedure of certain exercises in all the sections of the program, including the two recommended modifications in the cool down section. There were also responses regarding altering the dosage and the type of exercises. Responses covering other aspects for example causing injury were also there, though few but very significant.

Altering the procedure of an exercise

Related to altering the procedure, participants talked about preventing injury, focusing on vital components during the exercise for example scapular stabilisation and mobility, etc., especially during the warm-up phase (both 1 and 2). For example, with regards to arm circles, Participant 12 commented that "the long axis of the extended arm may add strain to some with existing injury or pathology. As an initial warm-up I'd suggest doing this with elbows flexed and only done with elbow extension once warmed up." In the same regard, participant 09 commented that "start arm circles with elbows flexed and remind the players to set their scapula down and wide for both exercises. I would either change abduction to a PNF pattern or add shoulder flexion as well." Meanwhile participant 08 on commenting about back-to-back overhead passes said that "this appears to demand high skill, precision and body awareness in space, therefore may not be suitable for warm-up. This can do well in skill development section- which can be another section before cool-down. Alternatively the athletes can be placed facing each other."

For serratus anterior strength in order to achieve optimal results, participant 09 suggested that the scapula be abducted and that a wall push upon press with a plus would achieve better results.

In the scapular stabilisers section with regards to altering the procedure, participant 12 suggested that "Again, just consider whether prone is the most appropriate position to get into. You could possibly adapt to do in forward-leaning supported seated."

Altering the dosage of an exercise

There were no suggestions with regards to altering the dosage for the warm-up section. However, it was a major trend in the strengthening exercises section. With regards to all the parameters of the FITT principle of exercise prescription, participant 09 suggested that "These players need strength endurance and not pure power. I would increase the reps and reduce the weight for 6 weeks and then add 6 and 1 rep max exercises after 6 weeks due to the and inky 1 per week due to the muscle breakdown that will occur." Participant 08 suggested that "I would prefer if start dosage was set at 8 reps," in addressing altering the dosage for IR strength.

Changing section of exercise

In the warm-up section, two exercises were suggested to change section from warm-up to a new section, skill development section, after cool-down. Participant 08 commented that "this appears to demand high skill, precision and body awareness in space, therefore may not be suitable for warm-up. This can do well in skill development section- which can be another section before cool-down. Alternatively the athletes can be placed facing each other."

In the strengthening exercise section, two exercises involving scapula movement were suggested to be moved to the warm-up section. "I think scapular mobilisation is a very important part of shoulder care and that this exercise should perhaps be moved to the warm-up section to ensure scapulae are mobile and activated before shoulder warm-ups." Participant 12.

The shoulder pain prevention programme

The final shoulder pain prevention programme, attached as *appendix XI* has been made up of the nine exercises that reached consensus in the first round and the modified exercises that had 100% agreement in the final round.

Discussion

The purpose of this research was to develop an exercise program that could be used to prevent shoulder pain in WB. To do this, a scoping review was conducted to identify exercises, if any, that have been recommended for the prevention of shoulder pain. Then, expert opinion was sought on the identified exercises to create a new program that was holistic.

There is limited research in shoulder pain prevention among wheelchair basketball players as evidenced by only the five studies identified in the scoping review. Moreover, only two of these studies were experimental studies. This is in agreement with all the studies included in the scoping review and Heyward et al (2017), who all pointed out limitations in research in this area. In addition to this, the two experimental studies included in the review (Wilroy & Hibberd, 2018; García-Gómez et al., 2019), adapted their exercise programs from swimmers and manual wheelchair users respectively. This study adapted the exercise program from studies that were for wheelchair athletes or WB basketball.

A systematic review done on studies for wheelchair sports (Heyward et al., 2017) reported no use of valid measurement tools in their included studies except for two studies. In this study, the two experimental studies included instruments that had been validated.

All the studies included in the scoping review focused on strengthening of the shoulder girdle muscles including the rotator cuff muscles and scapular stabilisers. The rationale for strengthening exercises according to these studies was to deal with the muscle imbalances prevalent at the shoulder. Rotator cuff muscles are active in both the push and recovery phases of wheelchair propulsion and during overhead activities (Mulroy et al., 1996; Vanlandewijck, Theisen & Daly, 2001). In addition to this, the repetitive nature of these activities during WB makes the rotator cuff prone to fatigue and overuse. Therefore, all the studies support strengthening of some or all rotator cuff muscles especially. Strengthening of posterior shoulder muscles, including trapezius, rhomboids, posterior deltoid, latissimus dorsi and rotator cuff has been encouraged as manual wheelchair users, including WB players, are reported to have relatively weaker posterior muscles compared to anterior muscles (Curtis & Black, 1999; Wilroy & Hibberd, 2018; García-Gómez et al., 2019).

Inclusion of warm-up in the included studies was variable. García-Gómez et al (2019) conducted active movements of the shoulder, as a warm-up, before strengthening exercises. In their study where expert opinion was sought for their home-based exercise program, García-Gómez et al (2019) reported this structure to be a valid structure of a home-based exercise program to maintain shoulder condition, in order to prevent development of shoulder pain among WB players. Curtis (1997) and Lee, McKay & Gutierrez (2020) also recommended beginning warm-up before strengthening exercises. According to Brukner & Khan (2017), warm-up prepares the body physically and mentally for exercise and so it is an essential component in injury prevention. In this regard, warm-up increases perfusion of blood to muscles from 15% at rest to about 70% (Hughes, 2002). This increased blood flow washes away waste substances and brings more oxygen for aerobic respiration, preventing lactic acid build up and in essence fatigue (Hughes, 2002).

Even though all the studies recommended inclusion of stretching exercises of shoulder muscles, evidence on the effects of stretching is still inconclusive (Hughes, 2002; Brukner & Khan, 2017). According to Hughes (2002), some studies even report an increased risk of injury due to a reduction of power and physical performance brought about by stretching before exercising. The majority of included studies (n=3) do not seem to agree with this concept as they recommend conducting stretches before strengthening exercises (Curtis & Black, 1999; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020). The two experimental studies however, did stretching after strengthening exercises and they found that it improved the range of motion of the shoulder (Wilroy & Hibberd, 2018; García-Gómez et al., 2019). In agreement with this, Brukner & Khan (2017) backed appropriate stretching, with caution not to overstretch and to warm-up before, to improve flexibility and range and to decrease risk of injuries. The stretches included in the various studies varied, with pectoral muscles and posterior shoulder stretches common in all the studies except Curtis (1997).

Members of the expert panel comprised of five physiotherapists and one sports scientist, with a minimum of five years of experience in WB or wheelchair sports. This was consistent with another study in which the majority of their sample were physiotherapists as well (García-Gómez et al., 2017). Their expert panel consisted of nine members in total, with four physiotherapists, three coaches, a rehabilitation physician and a sports physician.

In their study, García-Gómez (2017) reported that experts were providing specific responses with regards to the content, structure and sequence of the program. Similarly in this study, panel members were very specific in their responses. In this regard, panel members recommended alterations in procedures, dosages, type or even section of exercises for optimal function of the program. Recommendations were even made on perhaps varying the exercises in different weeks to avoid boredom or splitting the exercises so that they are conducted in different weeks.

During the third round of the Delphi, consensus was affected by dropouts. However, there was 100% agreement for some of the modifications and these were added to the programme.

To prepare the body for exercise, the proposed SPP begins with a warm-up consisting of active movements of the shoulder and scapula. Though some studies identified in the scoping review included warm-up in their programmes (Curtis & Black, 1999; García-Gómez et al., 2019; Lee, McKay & Gutierrez, 2020), the inclusion of scapula mobility in the warm-up is unique to this study. With scapula positioning and mobility vital in the development of SP among WB players, it was extremely necessary to focus on it from the beginning of the programme.

The proposed programme also includes strengthening exercises of the rotator cuff and other muscles of the shoulder complex. Previous studies have recommended strengthening of these muscles due to muscle imbalances and overuse observed in wheelchair athletes (Burnham et al., 1993; García-Gómez et al., 2017; Heyward et al., 2017; Wilroy & Hibberd, 2018). In comparing the strength of shoulder girdle muscles between WB players and able-bodied athletes, Burnham et al. (1993) found that WB players generally had stronger muscles. The rationale is that WB players use their upper limbs for function as well and considering most of the upper limb force production comes from the shoulder during hand rim wheelchair propulsion (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001), the shoulder muscles adapt. However, relative weakness of shoulder adductors to abductors and posterior muscles (scapulothoracic muscles) to anterior muscles has been reported in this group (Burnham et al., 1993; Curtis & Black, 1999; Aytar et al., 2015; Heyward et al., 2017; García-Gómez et al., 2019). In addition to this, WB players tend to present with overuse and fatigue of the rotator cuff muscles. This program is therefore tailored to address the specific strength deficits including strengthening of shoulder adductors including latissimus dorsi and pectoralis major, scapulothoracic muscles, rhomboids, trapezius and serratus anterior, and rotator cuff muscles. Strengthening of the biceps brachii has been included in the programme due to its role in dynamic stabilisation of the shoulder.

Furthermore, particular emphasis has been placed on endurance exercises for the shoulder girdle muscles before progressing to the strengthening exercises. WB players are involved in repetitive activity during the sport and ADLs including wheelchair propulsion and shooting. These repetitive activities are known to lead to muscle fatigue leading to overuse which has been highly associated with the shoulder pain among WB players (Van Der Woude et al., 2001; Vanlandewijck, Theisen & Daly, 2001; Heyward et al., 2017). Therefore, it was deemed vital to not only focus on pure strength but strength endurance. For the rotator cuff, muscle endurance exercises could prove to be a game changer as they are prone to fatigue because of their constant activity during the push and recovery phases of the wheelchair propulsion cycle (Vanlandewijck, Theisen & Daly, 2001; Boninger et al., 2002) and during shooting and passing to provide dynamic stabilisation of the GHJ (Veeger & van der Helm, 2007; Akbar et al., 2015; Heyward et al., 2017).Moreover, even though three of the studies (Wilroy & Hibberd, 2018; Riley & Callahan, 2019; Lee, McKay & Gutierrez, 2020) included in the scoping review did not specifically mention muscle endurance, their progression dosages for strength related more to endurance, with repetitions of >20 suggested.

Apart from fatigue of the rotator cuff muscles, WB players are also known to have altered scapula kinematics with the scapulae anteriorly tilted and internally rotated, leading to tightness of anterior structures of the shoulder and weakness of scapular stabilisers (Aytar et al., 2015; García-Gómez et al., 2019). In order to correct this, the SPP includes strengthening, mobility and activation exercises of scapula stabilisers. In keeping with this, Wilroy & Hibberd (2018) and García-Gómez et al (2019) included scapular retraction strength and strengthening exercises of other scapular stabilisers as part of their programmes. Burnham et al (1993) also thought it would be helpful to encourage scapular retraction and avoid the protracted scapula position. Taking this a step further, emphasis was also placed on mobility and appropriate positioning of the scapula during the strengthening exercises because of altered scapulohumeral rhythm that tends to happen (Aytar et al., 2015). It was therefore recommended that WB players should be given visual and verbal cues on mobility and positioning of the scapula during exercises that involve elevation and abduction of the shoulder. This study also includes scapular mobility during warm-up as scapular mobility and stability are vital in WB.

Interestingly, a new skills development section, was added to the program during the Delphi rounds. This section consists of sport specific exercises that involve hand rim wheelchair propulsion and shooting of a basketball. The inclusion of sport specific exercises in this program may be vital in preventing SP during the specific motions, including hand rim wheelchair propulsion and shooting, that have been associated with SP. Particular effort should be placed on ensuring that the correct technique is done during the exercises. According to Silva et al (2018), a good exercise program consists of both specific and general exercises. Even though this was specific to warm-up, it can be applied in our study as well. The stroke pattern or propulsion style has not been specified in this program but there is some evidence that supports the use of the semi-circular or under the rim stroke pattern as it tends to improve upper extremity function by having longer push angles and reducing initial braking moment, stroke frequency and power loss in manual wheelchair users (Boninger et al., 2002; Koontz et al., 2009; Kwarciak et al., 2009) . Improved function of the upper limb may in turn result in conservation of upper limb health (Kwarciak et al., 2009). However, this has not been directly associated with prevention of SP in manual wheelchair users, much less WB players. For WB players, considerations should also be made on the propulsion style in relation to prevention of SP and optimisation of performance or at the very least not negatively impacting performance. All in all, this still needs to be explored further.

Finally, stretching exercises were included in the cool down phase of the program. All the four stretches reached consensus agreement in the first round without any modifications. These stretches were targeting anterior chest muscles (pectoralis major and minor) which are reported to be tight due to poor posture (Vanlandewijck, Theisen & Daly, 2001; Yildirim, Comert & Ozengin, 2010; Aytar et al., 2015)and posterior capsule, upper trapezius, levator scapulae and internal rotators, which get tight when manual wheelchair users have limited IR ROM (García-Gómez et al., 2019) In agreement with this, all studies included in the scoping review recommended the inclusion of stretching in the prevention of shoulder pain among WB players and wheelchair athletes in general. The stretching exercises in the SPP have been included in the final section of the program, after all the other exercises of the program because evidence of stretching before exercising is still inconclusive. Moreover, García-Gómez et al (2017) found the structure of their SPP that placed stretching after strengthening exercises to be valid. In addition to this, Wilroy & Hibberd (2018) and García-Gómez et al (2019) reported improvements in flexibility as a result of their stretching exercises, which were done after strengthening exercises.

Conclusion and recommendations

Conclusion

Shoulder pain is a big problem among WB players. This study has provided a program that may be used its prevention among them. Apart from, aspects like strength and stretching, this study has included some other exercises including muscle endurance, activation of scapular stabilisers and skill specific exercises that may prove necessary in the prevention of shoulder pain among WB players. This is considered a strength of this study.

Clinical/practical recommendations

It is recommended that an assessment by PT or recognised professional i.e sports scientist should be done before implementing this program. Some exercises can be adjusted to the ability of the player. Moreover, when considering implementing this program, physiotherapists or coaches should consider strength endurance vs pure power and apply to the way their athletes are presenting.

In addition to the above recommendations, it is absolutely important for implementers to be aware of scapular position and mobility during exercises for effective implementation. Postural recommendations by Gómez (2018) may be considered when implementing this program as postural challenges are massive among WB players.

Recommendation for future research

Further research should be conducted on prevention of shoulder pain among WB players generally and with a focus on the classification as a confounding variable. Future research should consider closing the gap in causes of shoulder pain among WB players through longitudinal studies and the effect of implementing this program on incidence of shoulder pain among WB players.

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Strengths and limitations

This study has a number of strengths. Firstly, the methodology of the study consisting of a scoping review and a Delphi was perfect for this study because of the limited information on prevention shoulder pain among WB players. This study has explored options for prevention of shoulder pain among WB players in South Africa which to my knowledge has not been explored. Finally, the prevention program maybe be further explored and implemented.

This study, however, also has its limitations. Firstly, consensus was affected by low participation in the subsequent rounds of the Delphi. An expert opinion study is a low evidence study but was the design for the research question.

Appendix XI Shoulder pain prevention programme (SPP)

Note: Program conducted with the guidance of a physiotherapist or a trained exercise professional

WARM UP				
Goal: flexibility, mobility and to encourage correct movement patterns				
Exercise	**Position**	**Procedure**	**Equipment**	**Dosage (FITT)**
PNF D1 flexion extension	Sitting on a wheelchair	Starting with the shoulder flexed, adducted across your body and externally rotated, supinate forearm with elbow bent, then flex wrist and fingers with radial deviation such that your hand is resting on your opposite shoulder. Then move your arm diagonally across your body into shoulder extension, abduction and internal rotation, with the elbow extended, forearm pronated, wrist and fingers extended.	No equipment	1 minute
PNF D2 flexion extension	Sitting on a wheelchair	Start with shoulder flexed 180 degrees, abducted and externally rotated with forearm supinated, and wrist and fingers extended. Then move arm diagonally across your body into shoulder extension, adduction, internal rotation, with forearm pronated and wrist and fingers flexed	none	1 minute
Chest swings	Sitting on a wheelchair	Starting with both arms adducted on the chest with	No equipment/ 1 kg dumbbells	1 minute

		elbows flexed above 90 degrees, simultaneously abduct arms and retract and depress scapula at end range.	(1 in each hand)	
External rotation to internal rotation	Sitting on a wheelchair	Shoulder in neutral, stabilised to the body by a resistance band, then move the arm into internal rotation and then take it to external rotation	Theraband	1 minute
Abduction and elevation	Sitting on a wheelchair	With elbows flexed, raise arms into abduction and elevation for 30 seconds. Proceed to abduction and elevation with elbows extended for the last 30 seconds. ****Remind players to set scapula down and slightly wide. Demonstrate for them***	No equipment	1 minute
Scapular depression and abduction	Sitting on a wheelchair	With elbow straight, depress and retract scapula	None	1 minute
Scapular retraction	Sitting on a wheelchair	Shoulders neutral with elbows flexed 90 degrees, retract scapula while moving forearms outwards	None	1 minute
STRENGTH				
External rotation strength	Sitting on a wheelchair	With shoulder in neutral pressed against the body and elbow bent to 90 degrees while carrying a dumbbell, take hand and forearm out and then back to neutral	2kg Dumbbell and foam or towel	20 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest

				between sets for 6 weeks
Internal rotation strength	Sitting on a wheelchair	With shoulder in neutral pressed against body and elbow bent to 90 degrees while carrying a dumbbell, take forearm and hand close to abdomen and then back to neutral ****Exercise to be conducted in different positions as weeks progress starting with shoulder in neutral, then 90 degrees abduction and finally shoulder neutral but with hand behind back***	Dumbbell and foam or towel	20 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Serratus anterior strength	Sitting on a wheelchair	Sitted with shoulder in neutral and elbow bent 90 degrees, straighten elbow and lift shoulder up.	Dumbbells	20 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Biceps curls	Sitting on a wheelchair	Shoulders in neutral and elbows 90 degrees, lift forearm up.	Dumbbells	20 reps, 3 sets, 30 secs rest between sets for 6 weeks. Then 1 rep max, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Scapular depression and	Sitting on a wheelchair	Grab resistive band in front of wheelchair with	Resistive band	20 reps, 3 sets, 30 secs rest

abduction		elbow straight and depress and retract scapula		between sets for 6 weeks with light resistance band. Then resistive band of high resistance, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Scapular retraction	Sitting on a wheelchair	Shoulders neutral with elbows flexed 90 degrees, retract scapula while moving forearms outwards	Dumbbells	20 reps, 3 sets, 30 secs rest between sets for 6 weeks with light resistance band. Then resistive band of high resistance, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks
Shoulder adduction	Sitting on a wheelchair	Shoulders abducted 90 degrees, elbows extended, pull resistance band across to your body and return to starting position	Resistive band	20 reps, 3 sets, 30 secs rest between sets for 6 weeks with light resistance band. Then resistive band of high resistance, 10 reps, 3 sets, 45 seconds rest between sets for 6 weeks

Chest press (pectoralis major)	Supine on a bench	Shoulders abducted to about 90 degrees, elbows 90 degrees. Straighten elbows and shoulders and then return to starting position	Dumbbells	60% 1 rep max, 6 reps, 3 sets, 30 seconds rest
Lat pull up	Prone on a bench ***Positions can be modified for athletes that prone will be challenging**	Shoulders abducted to about 90 degrees and elbows flexed 90 degrees, pull up dumbbells and back	dumbbells	60% 1 rep max, 6 reps, 3 sets, 30 seconds rest
SCAPULAR STABILISERS ACTIVATION				
Y’s, ts ws	Prone ***Positions can be modified for athletes that prone will be challenging to a forward lean position or therapist’s discretion**	abduct arms to about 160 degrees, then keep moving them up and down (Y's) t's conducted with arms at 90 degrees abduction w's with arms at about 140 degrees abduction	No equipment	Low to moderate intensity
Lower trapezius activation	Lie prone on a bench ***Positions can be modified for athletes that prone will be challenging**	Abduct both arms to about 90-120 degrees. Then turn the arm so that the thumb is pointing downwards. Then lift the arms up and down.	Dumbbell	Low to moderate intensity
Serratus punch	Sitting on a wheelchair	Shoulder elevated to 90 degrees with elbow fully extended, move shoulder	Dumbbell	Low to moderate intensity

		forward and back		
STRETCHING (COOL DOWN)				
Pectoralis minor and major stretch	Sitting on wheelchair, shoulder and elbow flexed to 90 degrees	Place hand against the wall, then push your trunk forward while resisting with hand on wall	Wall or door	30 seconds hold
Upper trapezius and Levator scapulae stretch	Sitting on a wheelchair, shoulder in neutral position	Actively depress Rt shoulder and with Lt hand, assist lateral flexion of the neck to the Lt.	None	30 seconds hold
Posterior capsule stretch	Sitting on a wheelchair	Lift Lt arm across the body in horizontal flexion of 90 degrees and support it and increase motion with Rt arm on Lt arm's elbow. Repeat on Rt side	None	30 seconds hold
Sleeper stretch (external and internal rotators stretch)	Side-lying with pillow between knees.	While lying on the Lt side, take Lt shoulder out with elbow bent 90 degrees and wrist straight with fingers pointing up. Use Rt hand to slowly push Lt hand down as much as possible. Repeat on Rt side	None	30 seconds hold
SKILLS ACQUISITION/DEVELOPMENT				
Back-to-back overhead passes	Sitting on a wheelchair	With a partner and wheelchairs placed back-to-back, a basketball is passed overhead between the players with elbows extended	Basketball	
Back-to-back side passes	Sitting on a wheelchair	With a partner and wheelchairs placed back-to-back, a basketball is passed side by side	Basketball	1 minute

		between the players with elbows extended		
Forward and backward wheelchair propulsions	Sitting on a wheelchair	Propel wheelchair forward for 50m and backward for 50m	None	1 minute

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I TAWINA FF MSADALA (Student number: 2359654) am a student registered for the degree of master of science in physiotherapy in the academic year 2020.

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 included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: FF MS   Date: 30 September 2022