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Frequency and Location of Injuries in Wheelchair Basketball Players

Williams, Matthew

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Frequency and Location of Injuries in Wheelchair Basketball Players)

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Matthew Williams)

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Certificate of Ethical Approval

Applicant:

Matthew Williams

Project Title:

Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

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Abstract '

Background: Little knowledge exists detailing the frequency and location of injuries in wheelchair basketball. Equally it is uncertain if different athlete populations record different injuries and if they present with a predisposition to injury.

Objective: The objective of this retrospective questionnaire-based study was to provide an understanding of injuries within wheelchair basketball through the assessment of injury frequency and location. Whilst also aiming to understand factors which may predispose athletes to injury.

Method: Athlete information was obtained through two questionnaires. The initial questionnaire assessed athlete demographic factors including age, gender, classification, disability and playing standard. The second questionnaire recorded injuries sustained over the previous 12 months. Relative risk assessments were conducted to determine if certain populations presented with an increased injury predisposition.

Results: Injury reports recorded the shoulder as the most frequently injured location (31%) followed by the wrist (17%). Frequency of injuries differed across athlete age groups, gender, classification, disability and playing standards but the shoulder and wrist remained prominent locations. Relative risk assessment found athletes aged between 20-29 years (1.32), females (1.08), 1.0-1.5 classification (1.35), of spinal cord injury (1.27) and playing in the premier division (1.22) to have the greatest predisposition to injury.

Conclusion: The shoulder is the most frequently injured location in wheelchair basketball, and certain athlete populations across age, gender, classification, disability and playing standard display an increased predisposition to injury. The findings from this study will help future injury studies as well as in the development and application of injury reduction.

Table of Contents '

List of Equations

List of Tables '

List of Figures

1.1 Background

Wheelchair basketball (WCB) is one of the most popular disability sports in the world and has been part of the Paralympics since Rome 1960. As of 2015 the sport has an estimated 30,000 participants in approximately 100 countries worldwide (Cavedon *et al.,* 2015). Popularity of WCB has grown over the last 10 years with recent international competitions being aired no television for the first time.

Much like able-bodied (AB) basketball, WCB is a non-contact sport with teams comprising of five athletes per side. Games are of a high intensity and last 40-minutes and are split in to four 10-minute quarters, much like National Basketball Association games (IWBF, 2018). Multiple disabilities are represented within WCB with the most widely represented being spinal cord injury related disabilities (SCIR) – including spina bifida, amputees, and cerebral palsy (CP). Like all disability sports athletes, WCB players are classified according to their functional capabilities (Gil-Agudo *et al.,* 2010). The International Wheelchair Basketball Federation (IWBF) use a five-point classification system (Table 1.1.1) assessing athlete's abilities to sit upright, lean from side to side, forwards and backwards as well as how they shoot and pass (IWBF, 2018). Those classified as 1.0-point players have the highest degree of impairment and 4.5-point players the least level. Players classified as 5.0 are AB and as a result of having no functional impairment are only eligible to play in domestic tournaments. To compensate for the differences in functional capabilities, athlete's wheelchairs are modified to suit their classification. Low point athletes seat deeper in their chair and maximise lumbar support, whereas high point athletes sit higher and require less structural support (Vanlandewijck *et al.,* 2011).

1.2 Injuries within Wheelchair Basketball '

As with all sports, injuries occur within WCB, however the understanding of these injuries is limited (Curtis and Dillon 1985, Curtis and Black, 1999, Rocco and Saito, 2006, Patatoukas *et al.,* Willick *et al.,* 2013). Existing research has made several conclusions regarding injuries within WCB: primarily that injuries are common, with the shoulder being a common site of pain (Curtis and Dillon, 1985, Curtis and Black, 1999, Rocco and Saito, 2006, Patatoukas *et al.,* 2011, Yildirim *et al.,* 2010 and Willick *et al.,* 2013). However, current research lacks the detail, of injury frequency and location, with conclusions being made concerning common injuries being based on limited data. Therefore, one of the aims of this present study is to provide a more detailed understanding of injury frequency and location. The decision has been made to assess injury frequency and location over incidence and prevalence as research cannot progress into assessing incidence and prevalence rates without first establishing frequency and location.

Table 1.1.1: Wheelchair Basketball Athlete Classification

Class 1.0 Players
– Has no active trunk movement in the transverse plane – Has little or no controlled trunk movement in sagittal plane – Has no controlled trunk movement in the frontal plane – When unbalanced, has to rely on arms to return to the upright position
Class 2.0 Players
– Had active upper trunk rotation but no lower trunk rotation – Has partially controlled trunk movement in the sagittal plane – Has no controlled trunk movement in the frontal plane
Class 3.0 Players
– Has complete trunk movement in the transverse and sagittal planes – Has no controlled trunk movement in the frontal plane
Class 4.0 Players
– Has complete trunk movement in the transvers and sagittal planes – Has complete trunk movement to one side, but usually due to limited function in one lower limb
Class 4.5 Players '
– Has complete trunk movement in the transverse, sagittal and frontal planes '

To the knowledge of this present study no definition exists for injury frequency within a sporting environment. Thus, this study proposes the following definition, all injuries sustained by an injured population over a set time period. Injury location refers to the site as which the injury occurs. Incidence of injuries can be defined as the number of athletes who have sustained injuries over a given time period, whereas prevalence is the number of athletes who have an injury at the time of assessment (Nielsen *et al.,* 2017). From this incidence and prevalence can be expressed proportions i.e. the percentage of athletes with injuries, and incidence can also be expressed as an incidence rate – the rate in which new injuries are developed (Nielsen *et al.,* 2017).

1.3 Injury Reduction

Regardless of the sport in question reducing injury risk is an area of keen interest within sport for a number of reasons (Van Mechelen *et al.,* 1992 and Bahr and Holme 2003). Primarily if athletes suffer from injuries, it will directly affect their performance and potentially the team's performance, and in some cases, athletes are unable to return to full competition. There is also a financial cost to an injury, athlete will still be paid whilst injured and some injuries require external resources such as imagining and surgical intervention which will be funded. As a result, the increased interest in injury reduction is understandable.

Previously research has developed a model for conducting injury research (Figure 1.3.1). The model proposed by van Mechelen et al (1992) states first, it must be understood what injuries occur, before establishing the severity, thus highlighting common injuries. Then the aetiology and mechanism in which the injuries occur needs to be recorded as this may underline vulnerable movement patterns. From this an injury reduction strategy can be implemented before it is reassessed to determine its success. However, before this four-step process can be undertaken injury frequency and location must be recognised. Similar models exist, but the model of van Mechelen et al (1992) proposes a simple design that assesses injuries in sport.

Currently no available research exists exhibiting the use of injury reduction strategies within WCB. However, there is extensive use of these strategies within AB sport and recent research has demonstrated the effectiveness of these injury risk reduction programmes (Webster and Hewett, 2018, Heiderscheit *et al.,* 2010, Steib *et al.,* 2017, Hryosomallis, 2016 and Zarei *et al.,* 2018).Whilst it is not a direct aim or objective of this current study to create or implement injury reduction strategies it is a factor that this research will keep in mind to aid future research.

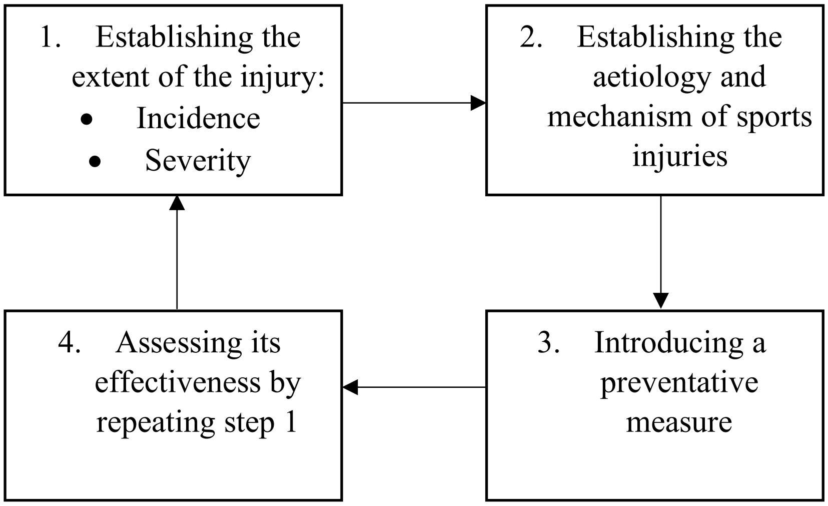


Figure 1.3.1: Four step process of injury prevention research, described by van Mechelen et al (1992), taken from Bahr and Krosshaug (2005).

1.4 Benefits of Injury Reduction

The presence of an injury may result in an immediate reduction to activity levels, and if consistent it can be detrimental to health. It is widely known that participation in physical activity has multiple health benefits reducing the risk of cardiovascular disease, contracting diabetes, cancers and reduces the risk of developing conditions such as osteoporosis (Warburton *et al.,* 2006 and Blair *et al.,* 2001). Equally, injuries can negatively impact on daily living, especially in individuals in disabilities. Thus, implementation of injury reduction strategies benefit both health and daily living.

Injuries are a negative event which cause temporary reductions in daily function and can lead to stress (Otter *et al.,* 2015). The presence of stress can lead to the development of anxiety and depression, all of which have been shown to reduce healing times and increase susceptibility to injury and illness (Gouin and Kiecolt-Glaser, 2011 and Nippert and Smith, 2008 and Ivarsson *et al.,* 2017). Stress is not the only mental health factor which can affect injuries. Mental fatigue which is a psychobiological fatigue caused from prolonged periods of demanding cognitive activity as seen from stress, anxiety or depression, can severely reduce an individual's energy levels and increase tiredness in turn increasing the predisposition to injury and reducing recovery (Marcora *et al.,* 2009).

Participation in physical activity has shown to aid mental health, reducing stress, anxiety and depression, whilst also reducing mental fatigue (Schuch *et al.,* 2011). It is evident that keeping athletes fit and injury free not only has a physical health benefit but also aids mental health and general health and wellbeing.

1.5 Predisposing Factors to Injury

A key component to a successful injury reduction strategy is highlighting predisposing factors to injury. Several risk factors to injury within AB have already identified by existing research and can be categorised as internal; directly relating to the athlete, or external risk factors; out of the athlete's control (Table 1.5.2) (Meeuwise, 1994 and Bahr and Home, 2003).

Table 1.5.2: Internal and External Risk Factors to Injury

Internal Risk Factors to Injury	External Risk Factors to Injury
Age Gender Body composition Health/Past medical history including disability (specifically spinal cord injury lesion-level) and functional capacities Physical fitness – Muscle strength/power ' – Maximal Oxygen uptake ' – Joint range of motion ' Anatomy Skill level Biomechanics – Technique Genetics	Human factors – Team mates – Opponents – Biomechanics Protective equipment Sports equipment Environment – Playing surface ' – Weather ' Training load – Intensity and volume – Season length – Match fixtures

The terms ‘risk factors’ and ‘predisposing factors’ are interrelated, by definition both relate to factors which modify the likelihood of an injury occurring (Hopkins *et al.,* 2007). However, in recent years the phrase predisposing factor has become more prominent, as a risk factor is deemed a fixed factor to increased injury occurrence whereas predisposing factors suggest a factor which can be modified. This present study will refer to predisposing factors over risk factors unless when referencing research articles.

1.6 Summary

Existing research within WCB has highlighted potential common locations of injury and predisposing factors to these injuries. However, current research has not extensively assessed injury frequency and location and therefore assumptions have been made on what injuries are deemed to be common in WCB without a comprehensive assessment of frequency and location. Furthermore, there is little understanding in the way predisposing factors to injury may influence WCB athletes.

1.7 Aim

1. ' To understand injuries in wheelchair basketball players.

1.8 Objectives

1. ' Identify frequency and location of injuries in wheelchair basketball players.
2. ' To understand which factors may predispose wheelchair basketball players to injuries.

1.9 Hypothesis

1. ' The most frequently injured location will be the shoulder.
2. ' Predisposing factors to injury will be highlighted in accordance to athlete age, gender, classification, disability and playing standard.

2.0 Review of Current Literature

The following review explores current research surrounding frequency and location of injuries within WCB athletes, whilst also discussing potential predisposing factors to injury. This review will initially explore the demands of WCB before discussing keys areas of research, namely defining and recording injuries, and how predisposing factors can influence injury frequency and location. Finally, limitations of research will be discussed, and suggestions made for this current study.

2.1 Background to Wheelchair Basketball

By nature, WCB is an aerobic sport compromising of four 10-minute quarters, with a 2-minute interval between the first and second periods of each half and a 15-minute break at half time. In a typical WCB game; of four 10-minute quarters, an athlete can travel 2680m at 1.48m/s with 2408 stop starts (Sporner *et al.*, 2009). The physical demand of WCB requires high intensity training to promote suitable physiological adaptations to compete at the highest level (Croft *et al.,* 2010 and Piovezana *et al.,* 2017).

As with all disability sports athletes in WCB present with disabilities that effect their physiology and function. For example, in persons with SCIR, reductions in peak ventilation, VO_2 peak, maximum heart rate and secretion of the hormones norepinephrine and epinephrine are experienced (Steinberg *et al.,* 2000, Price and Campbell, 2002 and Price and Campbell 2003). Furthermore, persons with high-level paraplegia; lesion between T1-6, see a greater reduction in these physiological parameters than persons with low-level paraplegia; lesion below T7 (Schmid *et al.,* 1998 and Price and Campbell, 2003). These reductions directly affect the athlete's aerobic capacity, which in turn effects performance-based fitness. The English Institute of Sport (EIS) have accommodated for physiological differences by issuing different fitness standards for each WCB classification (Table 1.1.1); based on current literature, with athletes classified as 4.0-4.5 performing at consistently higher level than 1.0-1.5 athletes (EIS, 2010, Molik *et al.,* 2010 and Yanci *et al.,* 2014).

2.2 Injury Definition

A crucial element of any study reporting on injury frequency is defining what an injury is. A wide range of definitions exist in literature but only those linked to WCB research have been included in this review. Any injury definition used must provide the reader with a clear understanding of what constitutes an injury. As whilst unsupported, a definition that is poorly defined may yield fewer reported injuries as a result of poor understanding. This current review will critique injury definitions based on the level and detail of information provided as well as the clarity of the definition.

2.2.1 Definitions in Wheelchair Basketball

Conclusions from five key studies assessing injuries within WCB state that injuries are an occurring factor within the sport (Table 2.2.1.3). Willick et al (2013) recorded WCB as the 10th highest reporting sport for injuries at the London 2012 Paralympic games with 16.8% of athletes reporting an injury. Curtis and Dillon (1985) showed soft tissue injuries represented 33% of injuries in wheelchair athletes, Patatoukas et al (2011) reported a higher rate of soft tissue injuries with athletes with CP at 58.9%. Studies by Bernardi et al (2003) and Rocco and Saito (2006) were the only studies to record locations and injury type, with the former stating 56% of injuries occurred at the shoulder and latter stating 25% of injuries were dislocations, fractures and repetitive strain injuries. Fundamentally findings from the above studies show injuries are a common factor within WCB. However, as Table 2.2.1.3 clearly shows all studies defined injuries differently and one study did not quote how injuries were defined, thus as injury definitions differ it is difficult to come to a true conclusion on injury frequency in WCB.

Table 2.2.1.3: Reported Injury Frequency in Wheelchair Basketball '

Study	Study Design	Injury Definition	Number of Subjects	Number of Injuries	Key Findings
Curtis and Dillon 1985	Retrospective	Any injury from the time of initial participation in wheelchair sports	128 (101 male 27 female)	291 (From 93 athletes)	33% soft tissue injuries, increased training hours related to higher number of injuries
Bernardi et al 2003	Retrospective	Any muscle pain during the past 12 months during sport activity at least 1 day	227 (169 male, 58 female)	115 participants recorded pain	56% shoulder injuries, with increased rate of prevalence of muscle pain with increased training volume
Rocco and Saito 2006	Retrospective	Not provided	26 (All male)	Not provided	35% of injuries were contusion (67% effecting the upper limb), 25% joint dislocations, fractures, and repetitive strain injuries, 15% sprains (80% in the upper limb)
Patatoukas et al 2011	Retrospective	Any injury that caused an athlete to stop, limit or modify participation for 1 day or more, all injuries in athlete's sport life included	139 (115 male and 24 female)	178 (From 69 athletes)	58.9% soft tissue injuries, with CP athletes recording more soft tissue injuries than other disabilities
Willick et al 2013	Prospective	Any sport-related musculoskeletal or neurological complaint prompting an athlete to seek medical attention, regardless of whether or not the complaint resulted in lost time from training or competition	3565 athletes at London 2012 (202 WCB athletes)	34 (from 202 athletes)	WCB had the 10th highest rate of injuries out of 22 sports, with 16.8% of athletes recording injuries. Injuries rates in males and females were similar

The quality of injury definition could influence a study's findings; a poor definition may yield poor results, and thus effect a studies reliability and validity. Curtis and Dillon (1985) use a broad definition providing no information on what constitutes an injury other than it must occur within wheelchair sport, therefore the reader must interpret themselves what they believe an injury to be. In contrast Bernardi et al (2003) use the term 'muscle pain' which provides detail on what an injury may include, however by definition this study would not consider any ligament, bone, tendon or neurological based injury as an injury, thus finding from Bernardi et al (2003) are unreliable in reference to overall injury frequency and location. More detail has been provided by both Patatoukas et al (2011) and Willick et al (2013). the former reports on time lost being a key factor in defining an injury whilst the latter reports on what structures may be included and requires the complaint to seek medical attention in order for its inclusion as an injury. The four definitions reported in Table 2.2.1.3 all differ in content, and thus will affect overall reported injury frequency and location. Therefore, any injury definition used within research must provide detail surrounding what an injury is but must also be clear in order to maintain reliability and validity of findings.

Another factor which must be considered when looking into the quality of a definition is the type of study design. All studies; bar one, were retrospective in design and of these four studies, three used questionnaires to record injuries. In these cases, as researchers are absent and cannot provide assistance to participants, they rely on the quality of the injury definition to record reliable and valid results. This further highlights the need to provide a quality definition in order to produce reliable and valid result. The only retrospective study within Table 2.2.1.3 that was not questionnaire based and did not provide an injury definition was that of Rocco and Saito (2006). Here the researchers opted to interview participants and therefore did not need a definition as they were able to communicate with the participants and determine themselves if their complaints were classified as an injury or not. Whilst providing an injury definition is important, the quality of the definition is dependent on the study design, studies that rely on questionnaires to record injuries require a quality definition. As this current study is aimed at establishing injury frequency and locations in WCB athletes a suitable injury definition must be used in line with the study design.

2.3 Recording Injuries within Wheelchair Basketball

Before carrying out a study into injuries within WCB, it must be established how injuries are recorded. A variety of designs are available, and the type of design adopted is dependent on the overall aims of the study. How these studies record these injuries again is dependent on the aim of the study, and this current review will be critiquing studies on how injuries were recorded.

2.3.1 Research Design

An injury-based study can either be retrospective or prospective by nature and as previously mentioned, all bar one study included in Table 2.2.1.3; Willick et al (2013), was retrospective by design. As these studies were aimed at highlighting how common injuries in WCB or wheelchair athletes were, a retrospective design was best suited as it enabled researchers to look back on previous incidents to determine general injury frequency. In contrast Willick et al (2013) was a prospective study, recording injuries reported by Paralympic athletes at the London 2012 Paralympic games, and thus were able to establish injury rates throughout the Paralympics. When the aim of a study is to gather a general understanding of injuries in sports a retrospective study is best suited, whereas if determining injury rates, or providing a real-time injury frequency and location assessment is the aim of the study a prospective design show be utilised.

2.3.2 Injury Recording Measure

Numerous studies have been conducted surrounding the locations of injuries sustained by WCB athletes (Table 2.3.2.4). These studies have primarily focused on the shoulder, and all have concluded that the shoulder is a common site of pain, and that individuals with SCIR suffer greater degrees of pain (Curtis and Black 1999, Curtis *et al.,* 1999, Sinnott *et al.,* 2000, and Yildirim *et al.,* 2010). Similarly, nonathletes have were also found to record higher levels of shoulder pain, however shoulder pain was still prominent in athletes (Fullerton et al., 2003).

All of the above studies were prospective by nature and used questionnaires to assess the level of shoulder pain. The most commonly used questionnaire was the Wheelchair Users Shoulder Pain Index (WUSPI) a reliable and valid tool which records individual pain across a number of daily activities, but is not specific to WCB (Curtis *et al.,* 1995). The WUSPI and similar questionnaires are focused on assessing an individual's level of shoulder pain and not concerned with identifying injuries. Whilst it can be argued that identifying pain will help predict which locations are likely sustain injuries, the two factors are separate entities. As a recent study has defined pain as an experience associated with actual or potential tissue damage that is affected by sensory, emotional, cognitive and social components (Williams and Craig, 2016). Thus, pain is not a predictor of injuries and merely an experience to an event which may or may not have resulted in an injury (Williams and Craig, 2016). Therefore, studies that assess pain in relation to injures can only conclude on the level of pain the individuals suffer or how prevalent pain is at a particular site. If a study wishes to identify common locations for injury are more suitable questionnaire should be used, one that is designed at identifying injuries as opposed to pain.

Table: 2.3.2.4: Reported Injury Location and Predisposing Factors in Wheelchair Basketball '

Study	Title	Study Design	Participant Demographics	Key Findings
Curtis and Black 1999	Shoulder Pain in Female Wheelchair Basketball Players	Descriptive self-reported survey	46 female athletes Average age 33±9 years old	Over 90% of athletes reported shoulder and upper-extremity pain.
Curtis et al 1999	Shoulder Pain in Wheelchair Users with Tetraplegia and Paraplegia	Descriptive self-reported survey	55 females and 140 males represented as 92 individuals with TP (average age 32.9±10.1) and 103 with PP (average age 34.4±10.7)	Athletes were TP recorded Performance-Correlated WUSPI scores 70% higher than PP athletes. Whilst both groups recorded the same aggravating activities, TP athletes recorded a higher intensity of pain. Age had no effect on the presence to intensity of shoulder pain.
Sinnott et al 2000	Factors associated with thoracic spinal cord injury, lesion level and rotator cuff disorders	Descriptive cross sectional self-reported survey	42 male athletes, 22 of which were high-lesion PP and 20 were low-lesion PP	82% of high-lesion PP and 40% of low-lesion PP were diagnosed with rotator cuff disorder. High-lesion PP athletes demonstrated a greater imbalance between shoulder ABD/ADD isometric strength on the non-dominant shoulder.
Fullerton et al 2003	Shoulder Pain: A Comparison of Wheelchair Athletes and Nonathletic Wheelchair Users	Descriptive self-reported survey	257 participants split in to athletes (172) (average age 34.34±10.11) and non-athletes (85) (average age 46.06±12.54)	66% of nonathletes and 39% of athletes recorded shoulder pain.
Yildirim et al 2010	Shoulder pain: A comparison of wheelchair basketball players with trunk control and without trunk control	Descriptive self-reported survey	60 athletes split into trunk control and no trunk control	Performance-Correlated WUSPI scores were higher on athletes without trunk control.
Wessells et al 2012	Concussion in Wheelchair Basketball	Descriptive self-reported survey	263 athletes, 188 males and 75 females with an average age of 25 years	6.1% of athletes reported concussion with female athletes being 2.5 times more likely to sustain a concussion.

The majority of research discussed in Table 2.3.2.4 has been conducted on the shoulder. Yet, there is no supporting evidence to suggest the shoulder is prime site for injury. Due to the nature of WCB and the demand on the shoulder it can be presumed the shoulder will be a common site in injury, but no available study has supported this claim. As a result, this current study will be designed to record all injury locations in order to determine which locations are common sites of injury.

One study included within Table 2.3.2.4 was the only study to be retrospective in design and not focused on the shoulder, instead assessing the presence of concussion in WCB. The study conducted by Wessells et al (2012) used a survey to identify individuals who had suffered concussion, providing them with a description on the signs and symptoms of concussion in order to record incidence. Although Wessells et al (2012) only focused on concussion incidents, it provides an understanding on how prevalent concussions are within WCB athletes and begins to paint a picture of injury frequency and location within WCB.

All of the studies within Table 2.3.2.4 have been descriptive questionnaires by nature; one study additional used a physical assessment on top of a survey. The advantage of this type of design is the ability to reach the wider population with relative ease. Unlike interviews or physical assessments where researcher would need to seek out their participants questionnaires can be issued out electronically, via post or to masses at an event or tournament. As research surrounding injury frequency and location in WCB is sparse this type of design will be best suited to develop a detailed injury report within WCB for this current study.

2.4 Predisposing Factors to Injury

Once injury frequency and location has been determined the next step in injury research is focused on reducing injury frequency. As shown in Figure 1.3.1 by van Mechelen et al (1992) once injury mechanisms have been identified prevention strategies should be implemented in line with the injury. However, it must first be understood if certain populations have a greater predisposition to injury.

2.4.1 Role of Predisposing Factors

Quite simply a predisposing factor is something that modifies an athlete's likelihood to an injury occurring (Hopkins *et al.,* 2007). How each factor influences an athlete's likelihood of sustaining an injury is dependent the effect the factor has on each individual and effected tissues. Once a predisposing factor has been identified it can then be assessed how the factor influences the athlete's predisposition to injury. It is the information gathered from this assessment that aids the selection of a prevention method to reduce injury risk. This present study will merely look to highlight potential predisposing factors to injury and not explore the mechanisms behind each factor.

2.4.2 Predisposing Factors in Wheelchair Basketball

No direct specific research has been conducted assessing predisposing factors within WCB. Whilst arguably this band of research is unnecessary as factors highlighted by Bahr and Holme (2002); as shown in Table 1.5.2, are predisposing factors to injury regardless of whether the athlete is AB or possess a disability. Available research assessing injuries within WCB athletes (Table 2.3.2.4) has suggested that an athletes' disability, functional ability (classification), age gender, and skill level may all predispose athletes to injury and therefore these areas will be the focus of this current review.

2.4.2.1 Age

Aging is a commonly discussed predisposing factor to injury, with the understanding that as athletes age their predisposition to injury increases (Faulkner and Brooks, 1995, Metter *et al.,* 1997, Doherty, 2003, Carmeli, 2003 and Nair, 2005). Not all injuries are a result to aging, many injuries sustained by adolescents are load related. In young athletes' bone growth precedes muscle, tendon and neural lengthening, thus a young athlete may become neuromusclarly 'tight' during peak growth periods and may result in acute or overuse injuries (Webborn, 2012). However, younger athletes (≤25 years of age) have already been shown to report lower injury rates when compared to older athletes at the London 2012 Paralympic games, and athletes aged 26-34 years of age reporting the highest injury rate (Willick, *et al.,* 2013). Younger athletes may have a reduced predisposition to certain types of injuries but display an increased predisposition in relation to acute or overuse injuries. Therefore, injuries are expected across all age ranges, and predisposition is dependent on the types of injury sustained.

2.4.2.2 Gender

On top of disability effecting athlete predisposition gender has been identified as a potential predisposing factor to concussions (Table 1.5.2). Female WCB athletes were 2.5 times more likely to sustain concussion compared to males (Wessells *et al.,* 2012). Whilst no explanation as to why females reported concussion 2.5 times more than males it clearly shows female athletes are predisposed to concussion and thus targeted injury reduction strategies can be implemented for female athletes to reduce predisposition.

However, the above research only discusses one injury and from existing research (Table 2.2.1.3) injuries to the shoulder are expected to be more frequent than those to the head. Current research has not extensive assessed injury rates in male and female WCB athletes, nevertheless Wessells et al

(2012) has highlighted a difference in concussion predisposition within gender and thus predisposition to other injuries may also be present upon assessment.

2.4.2.3 Disability and Classification

All WCB athletes have physical disabilities which impacts on their function, affecting parameters such as strength, mobility, biomechanics and even skill level, all of which are known predisposing factors to injury. Therefore, due to the effect athlete disabilities have on their function it can be hypothesised that disabilities can affect predisposition to injury.

Some pain research has already shown the effect SCIR have on the presence and intensity of shoulder pain. As shown in Table 2.3.2.4 studies by Curtis et al (1999) and Sinnott et al (2000) found athletes with tetraplegia (lesion-level C1-8) or high-level paraplegia (lesion-level between T1-6) recorded higher frequencies of shoulder pain and greater reduction in isometric strength compared to athletes with lesion-levels below T7. Thereby indicating the higher the SCIR lesion-level the greater the risk of developing shoulder pain.

Similar findings to that of Curtis et al (1999) and Sinnott et al (2000) have been found in athletes with reduced trunk stability. A study by Yildirim et al (2010) found athletes without trunk stability record higher WUSPI scores. In relation to WCB, athletes are classified in relation to their functional ability (Table 1.1.1) not disability, and athletes with trunk stability are classified towards the lower end of the scale (<2.5). Athletes with SCIR present with reduced trunk stability; higher lesion-levels seeing the largest reductions, and represent the majority of 1.0-2.5 classified athletes, other disabilities, such as severe cases of CP can present with similar reductions in trunk stability, and thus possess a similar increased predisposition to injury. The conclusion of Yildirim et al (2010) suggests athletes at a lower classification (<2.5), not just athletes with SCIR are more likely to sustain shoulder pain as a result of reduced trunk stability. Therefore, injury predispositions may exist in both athlete disabilities and classifications, and consequently both must be assessed as although they are interlinked, disability and classifications are different entities.

2.4.2.4 Playing Standard

Another potential predisposing factor to injury with WCB athletes was discussed by Fullerton et al (2003) (Table 2.3.2.4). The study found nonathletes recorded greater frequencies of shoulder pain compared to athletes (Fullerton *et al.,* 2003). The results suggest athlete have a reduced predisposition to injury compared to nonathletes, however 39% of athletes still recorded shoulder pain, so a predisposition amongst athletes may exist.

Based on the results of Fullerton et al (2003), athletes competing at a higher standard may be expected to report lower injury frequency rates that those at a lower standard. The mechanism behind this hypothesis is uncertain but the findings of Fullerton et al (2003) support it, therefore it is imperative to assess playing standard as a potential predisposing factor to injury

2.5 Limitations

A number of limitations exist within current literature surrounding frequency and location of injuries in WCB athletes. The following sections below discuss these limitations and the impact they have on this present research study.

2.5.1 Definition

Reporting injury frequency and location through questionnaire-based measures requires the use of an injury definition. There is no singular definition in scientific literature that is accepted for an injury and as a result definition between studies can greatly differ. Table 2.2.1.3 symbolises how vastly different injury definitions are within WCB research. It is evident from these definitions that the quality of definition differs between studies, with Curtis and Dillon (1985) and Bernardi et al (2003) providing little detail compared to Patatoukas et al (2011) and Willick et al (2013) (Table 2.2.1.3). The detail provided is crucial when assessing injuries, as a definition that does not clearly state what an injury is may produce inaccurate and unreliable results. Therefore, any definition used must provide detail on what an injury is, and criteria needed to be met before an event can be classed as an injury, as demonstrated by Willick et al (2013).

Equally the use of different definitions across multiple studies may affect validity as the definition will determine what injuries are recorded, thus influencing results. For example, by definition Willick et al (2013) will have recorded injuries that Bernardi et al (2003) would have not considered as injuries, consequently the two studies will quote vastly different findings regarding injury frequency and location. Fundamentally, it is difficult to compare findings between studies that use vastly different definitions as they are potentially reporting on completely different injuries, however any definition used must clearly state what an injury in order to produce reliable, valid and accurate results.

2.5.2 Pain

Many studies (Table 2.3.2.4) have used pain as a marker for assessing athletes' function and highlighting those at risk to pain. Whilst these conclusions on pain research may help predict injury frequency the presence of pain, whilst common after an injury event, does not mean an injury has occurred. For instance, in the days following an intense WCB training session an athlete may experience pain in the form of delayed onset muscle soreness as a result of the training session. Here the pain is in response to the session and does not mean the athlete is injured but if they were to complete the WUSPI questionnaire post training session it can be hypothesised pain levels would be higher. Whilst it was the aim of these studies to assess pain not injuries, it still highlights a key point that when analysing injuries in relation to frequency and location it is imperative to record injuries and not assess pain levels.

2.4.3 Injury Diagnosis

The overwhelming majority of studies conducted their assessment through the use of a questionnaire (Table 2.2.1.3 and 2.3.2.4). Only Willick et al (2013) and Sinnott et al (2000) conducted a physical assessment to either record injuries or support the questionnaires findings. Studies that relied purely on a questionnaire to record injuries require the athlete to correctly identify the injury. Whilst athletes will reliably and accurately identify where there injured occurred, they are unlikely to be able to identify the cause. For instance, Bernardi et al (2003) recorded 56% of injuries at the shoulder however, some of these reported shoulder injuries may be a result of damage to non-shoulder related structures such as the cervical spine which commonly refers pain into the shoulder. By conducting a physical assessment researcher can gain more detail regarding the injury compared to questionnaires and ultimately determine the exact injury location. This can also be achieved through an interview as done by Rocco and Saito (2006), however both interviews and physical assessments can be time consuming and if the same researcher is not completing the assessments the procedures must be standardised to secure validity. Despite this completing a physical assessment or conducting an interview (formal or informal) allows researchers a greater understanding of the athlete's injury and may increase the reliability and accuracy of results.

Although conducting a physical assessment enables researchers to gain a greater understanding of the injury, not all assessments are reliable and valid. After completion of questionnaires athletes in the Sinnott et al (2000) study took part in a physical assessment which include impingement sign testing, postural assessment and isometric strength assessments. Research has shown impingement sign testing to have poor reliability and validity with tests; even when used as part of a cluster, are highly sensitive but lacking specificity (Macdonald *et al.,* 2000, Calis *et al.,* 2000, Michener *et al.,* 2009, Kelly *et al.,* 2010 and Hegedus *et al.,* 2012). Equally isometric strength testing lacks test-retest reliability and may only demonstrate if a muscle is strong not how strong it is (Malerba *et al.,* 1993 and Katoh, 2015). Another study conducted by Willick et al (2013) conducted a physical assessment as part of their assessment, however these were conducted by potentially hundreds of healthcare professionals linked to national Paralympic teams and thus it is near impossible to find out what procedures were conducted. Despite this, research has shown that physical assessments, particularly at the shoulder are unreliable in relation to diagnostic accuracy and validity but are useful in determining the exact location of the injury.

2.5.4 Questionnaires

The vast majority of studies within this review recorded injuries through the use of a questionnaire. The use of a questionnaire enables researchers to assess populations over vast distances with relative ease. Questionnaires must demonstrate good reliability and validity in order to produce accurate, reliable and valid results. The majority of studies in Table 2.3.2.4 used the WUSPI, whilst studies that used questionnaires within Table 2.2.1.3 provided no details on these questionnaires used, and their reliability and validity cannot be assessed. Although Curtis et al (1995) reported high test-retest reliability (ICC=0.99) and high internal consistency (α=0.67) of the WUSPI, it is not a suitable tool for assessing injury frequency or location as it merely focuses on pain at the shoulder. It is essential when using a questionnaire to record injuries it must fit the design of the study, when assessing injury frequency and location a questionnaire must do that. Furthermore, a questionnaire must be simple to understand and quick to complete, one that is to complex and time costly may affect response rates.

Expected response rate for a questionnaire-based study is between 10-15%, and thus studies must seek a wide sample size in order to produce reliable, valid and accurate results.

2.5.5 Injury Location

Much of injury location research works on the assumption shoulder pain and injuries are common in WCB athletes (Table 2.3.2.4). Suitable predictions based on the nature of WCB can be made that may suggest the shoulder is a common location for injury, however no research definitively supports this. Rocco and Saito (2006) stated injuries in the upper-limb were more common than the lower-limb but did not state where in the upper-limb they occurred. Although Bernardi et al (2003) reported that 56% of injuries were sustained at the shoulder, the study only focused on muscle pain and did not consider joint, bone, ligament or tendon injuries as such, thus overall injury frequency and location results are unreliable. It is evident that existing research has jumped to the conclusion that shoulder injuries are common in WCB athletes with little to no supporting evidence to support this claim. As a result, this current study will aim at highlighting specific injury locations to determine the most frequently injured sites.

2.5.6 Sample Size

The sample size of a study impacts the reliability and validity of results, a sample that is too small may produce results with poor reliability and validity. From studies presented in Table 2.2.1.3 and 2.3.2.4 the sample size ranged from 26-263 participants. Rocco and Saito (2006) had the smallest sample size of 26 but as they opted to interview athletes opposed to questionnaire, they were able to get greater detail surrounding injury frequency and location compared to many larger studies such as Curtis and Dillon (1985) and Patatoukas et al (2011). If a study presents with a low sample size it must compensate for this by providing greater degrees of details in order to maintain reliability and validity.

2.6 Summary

From reviews of current literature surrounding injury frequency and location in WCB athletes it is clear several limitations to research exist. The presence of these limitations will aid in the structure of this current study. Existing research has yet to identify injury frequency within WCB but has begun to identify injury locations (Table 2.2.1.3 and 2.3.2.4) their prevalence has been presumed through the absence of a detailed injury frequency study. Furthermore, a lack of consensus on defining an injury (Table 2.2.1.3) has led to research reporting vastly different frequency rates. In reference to injuries in different populations, research has identified persons with SCIR are more susceptible to injury but have not assessed all disabilities within WCB, nor has research comprehensively assessed athlete classification in relation to injury frequency. Considering these limitations this present study will use a clear injury definition in which athletes feel best describe an injury. Efforts will be made to assess a diverse group of athletes across a variety of ages, playing standards disabilities, classifications and equally assess male and females. Finally, similar to existing research this present study will adopt a retrospective questionnaire-based design in order to assess the wider population of WCB athletes and establish a baseline injury frequency and location report.

3.0 Methods

The following sections detail the methodology of this retrospective questionnaire-based study. A summary of the methodological procedures is summarised in Figure 3.0.2.

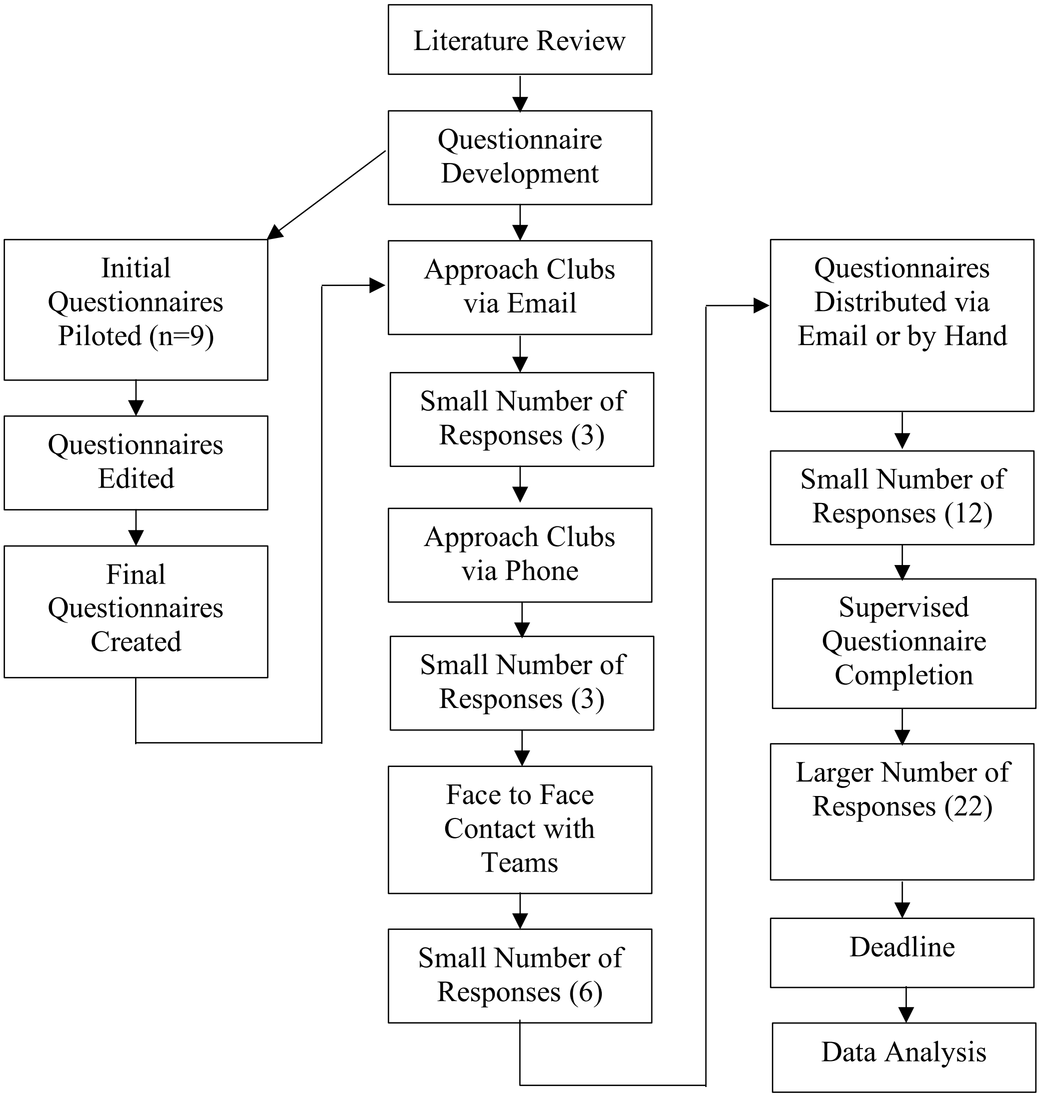


Figure 3.0.2: Development of methodology regarding questionnaire development, distribution and analysis.

3.1 Ethics and Consent

Ethical approval for the study was provided by Coventry University Faculty of Health and Life Science (P43097) (Appendix 1).

Gatekeeper consent was received through signature of a gatekeeper's letter (Appendix 2) provided by a chairman, president or head coach of the designated team. Informed consent (Appendix 3) was obtained from each individual athlete after they were informed on the requirements of the study, but before questionnaires were distributed. In the event of an athlete being under 18 years of age a parent/guardian was required to sign both an individual gatekeeper's letter (Appendix 4) and the informed consent document before questionnaires were issued. Parents/guardians were also briefed about the study and their son/daughter's involvement within it. The researcher had already obtained a valid DBS prior to submission for ethical approval.

3.2 Study Design

Due to the lack of research assessing frequency and location of injuries within WCB the present study needed to be able to establish a baseline understanding on injury frequency and location. As a result, the current study is a retrospective descriptive questionnaire based self-survey. This design falls in line with the design of existing research within this area making the approach directly comparable. However, there are a number of limitations with this type of study design namely the reliability and validity of the questionnaires used. As the questionnaire asked athletes to record their injuries, it relies on them being able to remember what injury they had and answer the subsequent questions as accurately as possible. However, this type of design enables researchers to access a large population with relative ease.

3.3 Participants and Recruitment

Participants were recruited from 12 WCB clubs (approximately 300 athletes in total) across the United Kingdom. No exclusion criteria were put in place as it was essential for as much data to be collected as possible. All teams were registered WCB within the British Wheelchair Basketball league system either representing teams in the premier division (the highest tier) division 1, division 2, division 3 or in the junior leagues.

Contact details for team managers and coaches were freely available on the British Wheelchair Basketball website. Initial contact with teams was conducted through email however, this resulted in a poor response rate (3 teams), which prompted contact being made through telephone communication. Whilst response rates improved (a further 3 teams responded) difficulties were still experienced in gaining formal consent. Therefore, face to face contact was made with the relevant team managers and coaches to gain consent.

Upon consent being gained for a team, the researcher contacted athletes either directly through email or when possible were distributed after face to face contact with players. During this contact time athletes were instructed on the purpose of the study and their role within it. Once consent was received, they were issued with participation information sheets (Appendix 5) and questionnaires (Appendix 6 and 7).

3.4 Development of Measures and Data Collection

As no existing injury or demographic questionnaires within WCB could be found that met the scope of this study, two questionnaires were created, a demographic and injury questionnaire. Before the injury questionnaire was finalised, a development process was undertaken to create suitable questions (Figure 3.0.2). Following research on existing questionnaires, the initial injury questionnaire was created and piloted to a small group of athletes (n=9) from the Coventry Wheelchair Basketball Academy. Feedback on the questionnaire, included providing examples of a completed questionnaire so participants can see how to complete the questionnaire and removing unnecessary use of scientific terminology which participants may not understand, such as, sprain, strains or oedema. The aim of this process was to improve the general ease of completion. Equally, the pilot group were also used in selecting an injury definition that they understood and best represented what an injury is. The following injury definition was provided in the questionnaire ' and was based on the definition provided by Willick et al (2013), 'any musculoskeletal or neurological complaint prompting an athlete to seek medical attention, regardless of whether or not the complaint resulted in lost time from training or competition'. Both the researchers and athletes felt this definition best represented an injury without overcomplication.

No studies were conducted to report on the reliability and validity of the questionnaires developed for this study, demonstrating a limitation with this study. However, the questionnaires were piloted, and the researchers deemed this a suitable limitation as existing questionnaires did not meet the demands of this study. The overall reliability and validity of these questionnaires will be discussed in later sections, but the questionnaires are considered to be trustworthy.

The demographic questionnaire; based on the questionnaire of Curtis and Black (1999), recorded 16 principle questions, with athletes being questioned on gender, age, wheelchair use, hand dominance, disability, WCB experience, playing standard, training habits, occupation, activity participation, driving status and athlete perceived fitness level. Athletes were given an example questionnaire (Appendix 8) to which athlete were encouraged to reference when completing their questionnaire. The example questionnaire was provided in an aim to minimise questionnaire errors.

Recording demographic data was essential in this study as it provided information that could potentially present as predisposing factors to injury, such as age, gender, disability and playing standard (Minagawa *et al.,* 2013, Carmeli *et al.,* 2003, Bahr and Holme, 2003, Yildirim *et al.,* 2010, Sinnott *et al.,* 2000 and Gabbett, 2016).

The injury questionnaire required athletes to record any injuries sustained over the last 12 months. A 12-month period was chosen as it covered a full WCB season including, off and preseason and enabled researchers to identify if there was a time periods during a WCB season when athletes were more susceptible to injuries, rather than generally being injured. To further understand frequency and location of injuries and how certain factors may predispose athletes to these injuries, questions were asked regarding, mechanism of injury, activity in which the injury occurred, diagnosis and treatment of injury, how much time was missed due to the injury and when the injury occurred. An example of the injury questionnaire was supplied to each athlete before they completed it (Appendix 9).

Athletes were also asked to record their general fatigue, recovery and fitness on a 10-point scale, with 0 representing no problem with fatigue, recovery or fitness and 10 representing noticeably feeling fatigued, struggling to recovery and struggling to maintain performance. Athletes were instructed to base the response to these three questions on current fitness level. Researchers were aware that this is a novel way of assessing fatigue, but it was included as a way to understand how athletes perceived their own ability to cope with the demands of WCB and their ability to recover between training sessions and games. This was deemed an essential requirement due to the growing body of research highlighting overtraining and poor recovery to increased predisposition to injury (Laux *et al.,* 2015 and Gabbett, 2016).

Arrangements were made with athletes from each team to return questionnaires at a set time (normally within one week). In certain cases, questionnaires were collected by coaches and then passed on to the researcher at a later date. However, as participants were not pressured to complete the questionnaire upon distribution a poor return rate was seen, 12 completed questionnaires were returned leaving approximately 60 that were not returned. After the initial poor return rates, participants were encouraged to complete the questionnaire upon distribution, which saw a greater return rate.

3.5 Data Analysis

Initially athlete demographic characteristics and injury data were analysed using descriptive statistics. Injury data is displayed as a percentage with the relative number of injuries presented alongside the percentage figure. To assess whether different populations presented with increased predisposition to injury, relative risks (RR) were also calculated. The RR was defined as the likelihood of occurrence after exposure to a risk variable compared to the likelihood of occurrence in a control group (Andrade, 2015).

The process of calculating RR is shown in equation 1 in which the risk in the exposed group is divided by the risk in the non-exposed group. The exposed group represents the population sample in which RR has been assessed. In the current study assessment were made within athlete age groups, gender, classifications disabilities, and playing standards. These groups were then broken in to sub-groups to provide a more thorough assessment. The non-exposed groups represent the population that has not been exposed to the same parameter as the exposed group, for instance when assessing RR in under 19s, they will form the exposed group and age groups 20-30, 31-40 and 41+ will be combined together to form the non-exposed group as they are not under 19 years of age.

$$\text{Relative Risk} = \frac{\text{Risk in Exposed Group}}{\text{Risk in Non-Exposed Group}} = \frac{a/\,(b + c)}{x/\,(y + z)}$$

Equation 1: Determining Relative Risk

To determine the numbers are inputted into equation 1 a simple table can be devised (Table 3.5.5). It must first be calculated how many injuries were sustained by individuals within the exposed group (b) and how many did not sustain an injury (c). This process was repeated within the non-exposed group (y and z, respectively). The total of injuries and non-injuries recorded in each group was calculated before the two numbers were divided against one another to give the RR.

Table 3.5.5: Table depicting how numbers are inputted in the relative risk equation.

	Injuries	No Injuries	Row Total
Exposed Group	b	c	a
Non-Exposed Group	y	z	x

A RR greater than 1.0 depicts a potential increase to risk of sustaining an injury within that group, whilst an RR lower than 1.0 indicates the risk is lower in the exposed group (Andrade, 2015). All raw data and RR calculation are shown in Appendices 10-15.

4.0 Results

4.1 Athlete Data

A total of 34 athletes participated in this study, with an average age of 27.5±11.8 years (Table 4.1.6). The majority of athletes were male representing 70% (24) of the population size, and females represented 29% (10).

Table 4.1.6: Average age according to athlete age groups and gender '

Age Group	Distribution (% | n)	Mean Age	Male	Female
Whole Group	- | 34	27.5±11.8	30.1±12.7 (24)	21.3±6.4 (10)
<19 years	38 | 13	16.9±1.9	17.2±1.6 (9)	16.3±2.3 (4)
20-29 years	23 | 9	24.4±3.0	25.7±3.0 (6)	22.0±1.0 (3)
30-39 years	18 | 6	34.3±2.3	35.5±1.9 (4)	32.0±0.0 (2)
≥40 years	18 | 6	48.2±4.1	48.2±4.1 (6)	N/A

A variety of disabilities were represented within the population size (Figure 4.1.3). Athletes were represented in accordance to their WCB classification (Figure 4.1.4), whilst Figure 4.1.5 demonstrates how athlete disabilities and classifications interrelated. More detail regarding athlete disabilities is discussed in section 4.4.5.

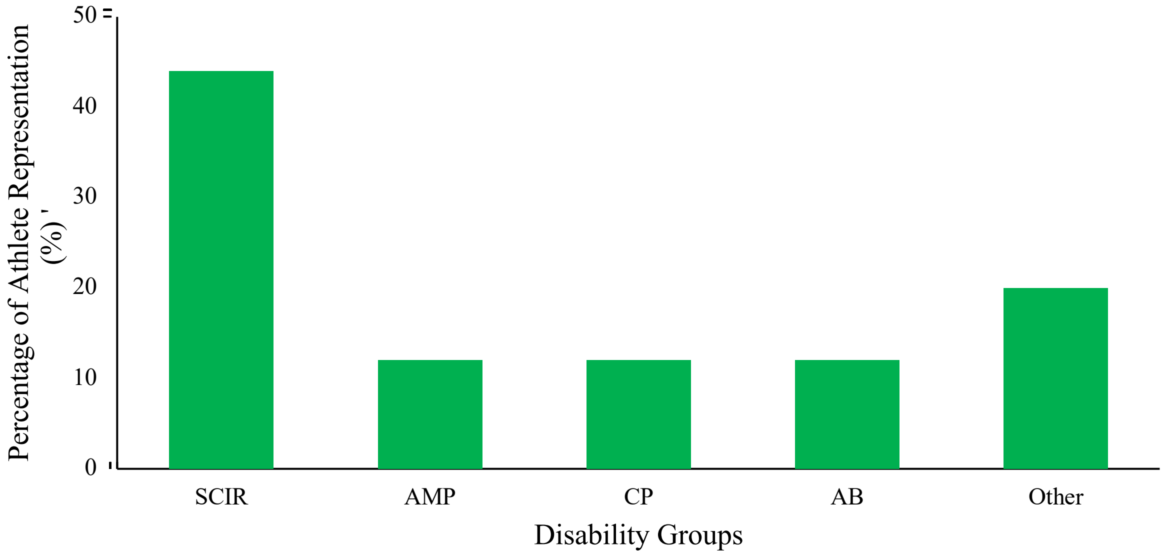


Figure 4.1.3: Representation of different disability groups.

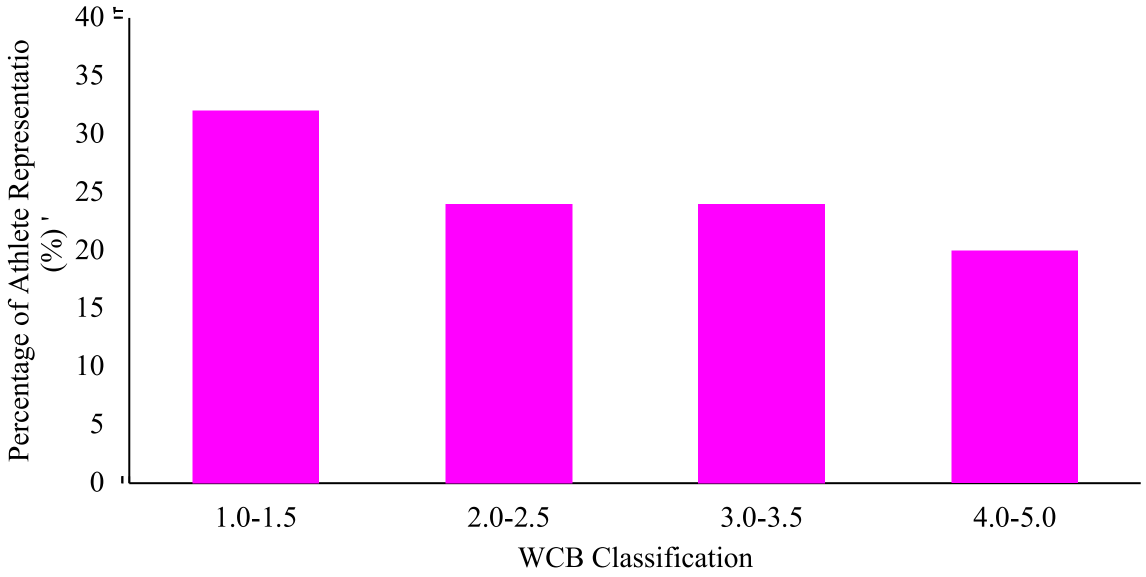


Figure 4.1.4: Athlete representation according to classification group.

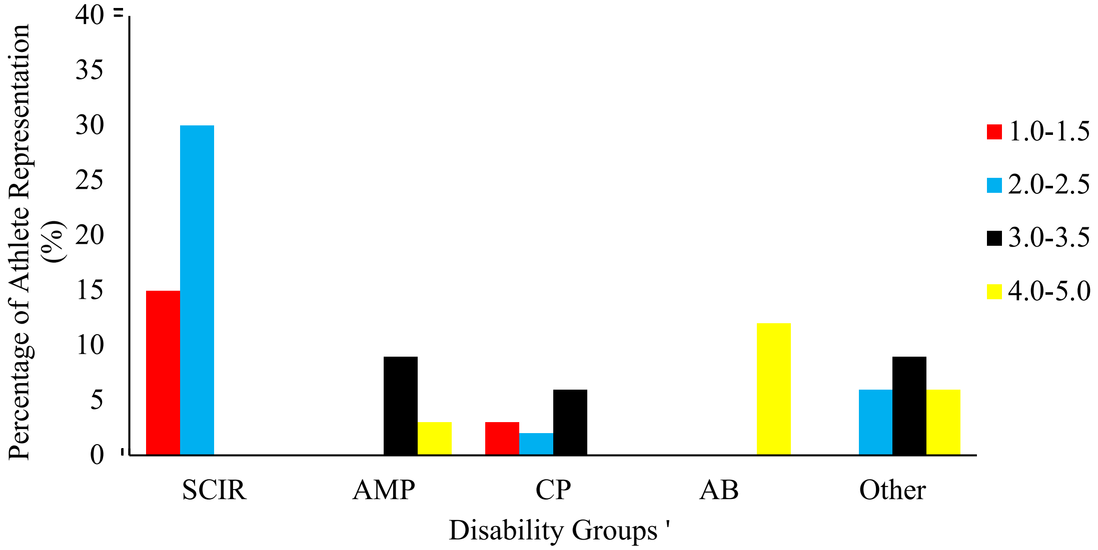


Figure 4.1.5: Disability representation across classification groups.

The playing experience athletes equated to 8.5±7.4 years. The use of a wheelchair (from point of dependency) across the athletes was 16.5±24.8 years.

4.2 Training Demographics

All except two athletes (one male and one female) participated in WCB competitively in British Wheelchair Basketball leagues (Figure 4.2.6). The majority of athlete compete in the 1st and 3rd divisions. The two non-competing athletes still regularly trained with a WCB team and was registered to compete. Nearly half of the population 44% (15) had represented or currently represented their national team. The number of weeks training per year across all athletes was 40.0±17.2, with approximately 2.3±1.5 training sessions per week, lasting a duration of 5.5±3.5 hours.

All athletes considered themselves fit for participation in WCB, with reported fatigue (at the time of completing the questionnaire) was 4.4±2.2, the average recovery between sessions was 3.0 ±1.9 and the average athlete perception of their ability to meet the demand of WCB was 3.0±1.7.

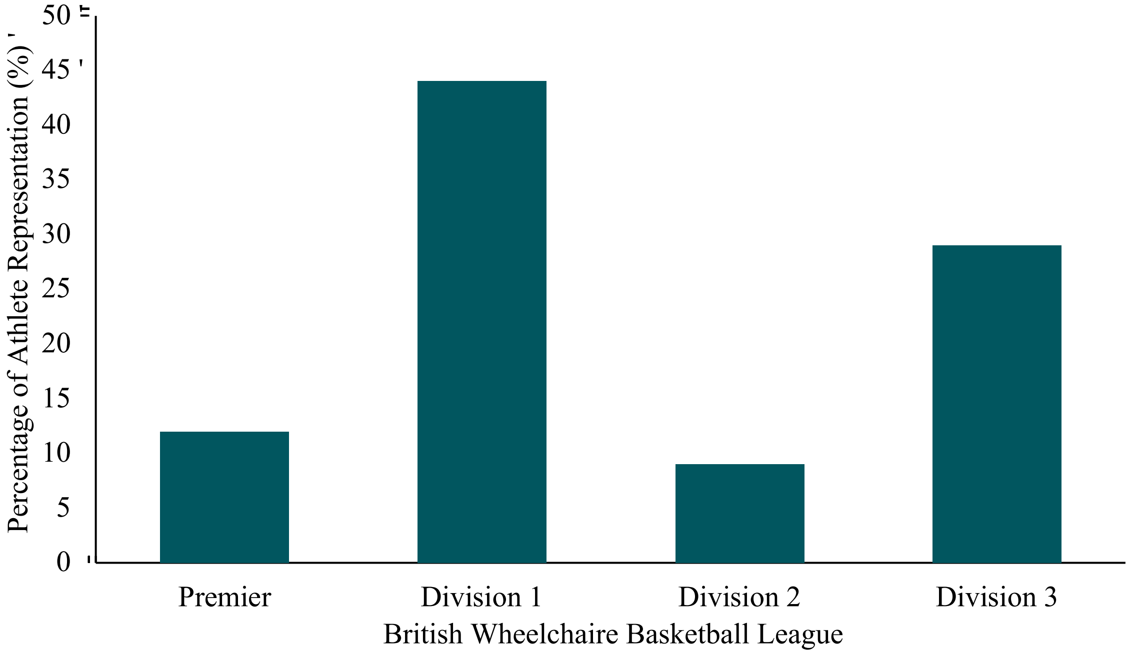


Figure 4.2.6: Athlete participation within British Wheelchair Basketball leagues.

4.3 Activity Demographics

Of the 34 participants 70% (24) participated in at least one activity outside of WCB, 78% (27) participating in 1-2 activities outside of WCB and 22% in 3 or more. The gym and strength and conditioning were the most common activities with 57% (20) participation (Figure 4.3.7) On top of the training for WCB, participation in the above activities added 3.0±4.2 training hours per week from 1.8±1.6 training sessions.

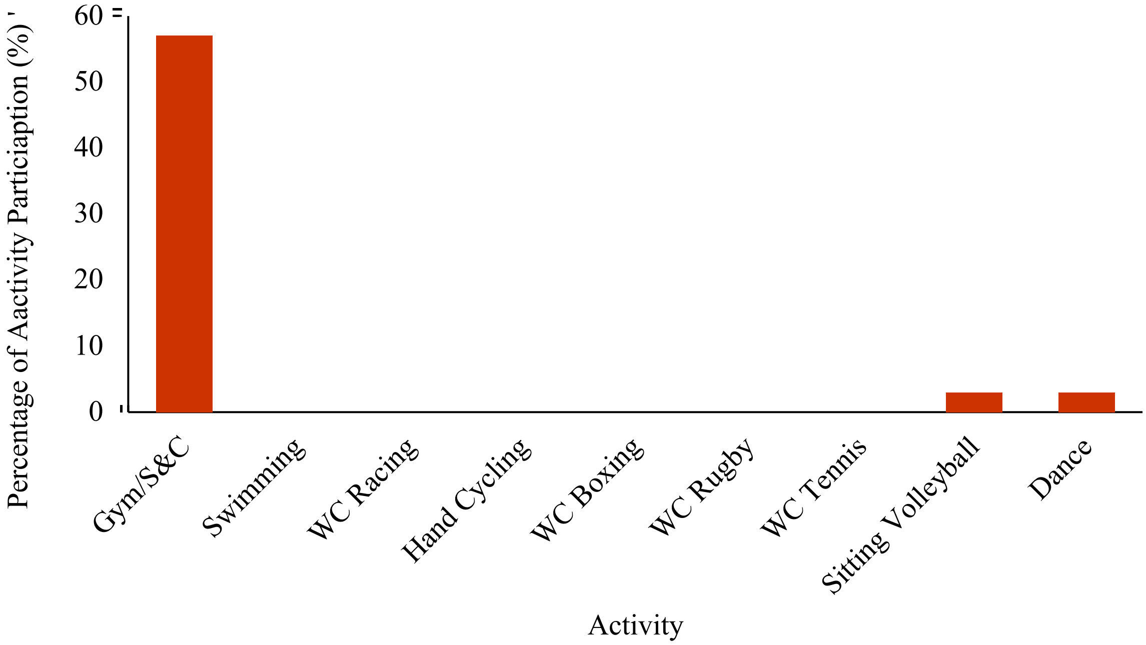


Figure 4.3.7: Athlete participation in secondary activities.

4.4 Injury Data

A grand total of 62 injuries were recorded from 82% (28) of the participants, equalling 1.82 injuries per athlete. Of the 62 injuries 35% (22) were currently ongoing, and of the injured population, 64% (18) recorded more than one injury. Although it was recorded when injuries were sustained in relation to the WCB season, analysis showed no particular time point in which injuries were sustained more frequently than others.

The key finding from this study is highlighting the most frequently injured locations which were recorded at the shoulder and wrist. The shoulder represented 31% (19) of total injuries and the wrist recording 18% (11) of injuries (Table 4.4.7). Crucially Figure 4.4.8 shows injury frequency and location trend is similar to that reported across all Paralympic sports at London 2012 Paralympic games.

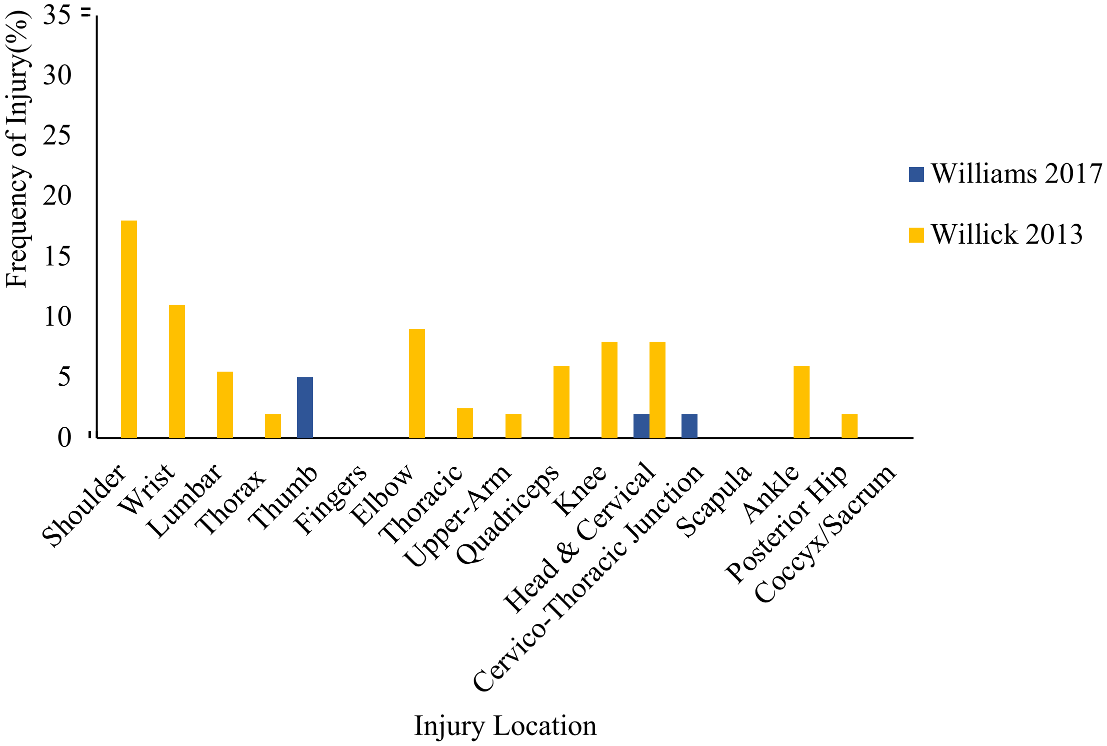


Figure 4.4.8: Comparison of injury frequency and location in WCB, and across all sports at the 2012 Paralympic games.as reported by Willick (2013).

Table 4.4.7: Injury Frequency and location for all reported cases (62 injuries). '

Injury Site	Number of Injuries	Percentage of Injuries
Shoulder	19	31
Wrist	11	18
Lumber Spine	4	7
Thorax	3	5
Thumb	3	5
Fingers	3	5
Cervicothoracic Junction	3	2
Elbow	2	3
Thoracic Spine	2	3
Upper-Arm	2	3
Thigh	2	3
Knee	2	3
Posterior Hip	2	3
Head and Cervical Spine	1	2
Scapula	1	2
Ankle	1	2
Coccyx/Sacrum	1	2

4.4.1 Mechanism of Injury

Specific mechanisms of injuries in relation to the injuries reported in Table 4.4.7 (Figure 4.4.1.9). Overuse was the most common mechanism of injury and included references to wheelchair propulsion, repeated wheelchair lifting, daily activities and overtraining. Mechanisms relating to WCB technique (including catching ball in frontal plane) and falls from wheelchair were also prevalent. Remaining mechanisms were only responsible for a small number of injuries.

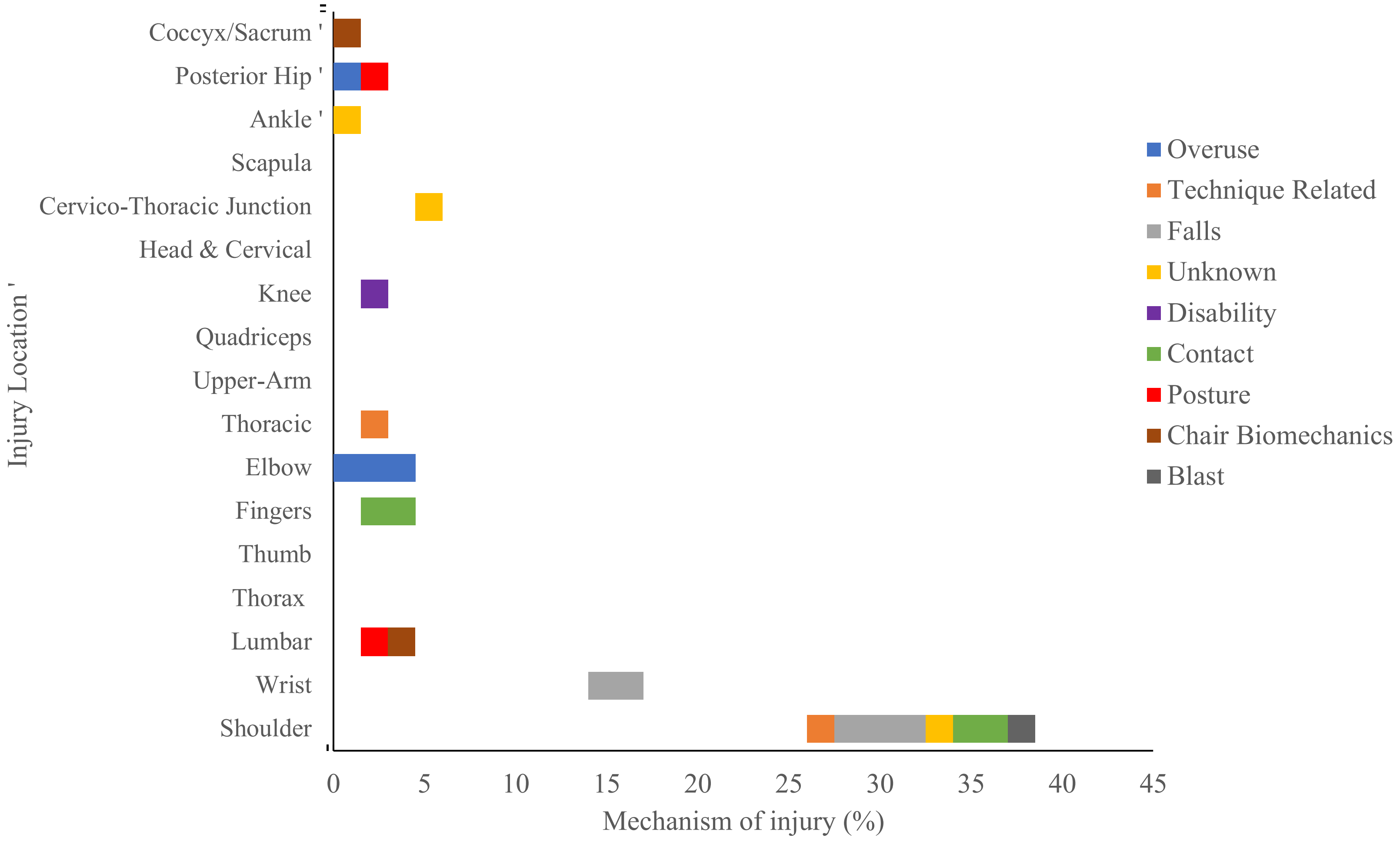


Figure 4.4.1.9: Summary of mecahnsisms of injury in relation to reported injuries.

4.4.2 Age

Assessment of injury frequency and location was conducted across a variety of age groups (Figure 4.4.2.10), with Table 4.1.6 displaying athlete representation across age groups. Results indicate injuries across all age groups are common. Under 19s reported 37% (23) of total injuries, whilst athletes aged between 20-29 recorded 29% (18) those aged between 30-39 recorded 11% (7) and 40+ aged athletes reported 23% (14). In terms of injury location, the shoulder was a main site of complaint recording 30% (7) of injuries in under19s and 43% (3) in both 30-39 and 40+ age groups. The 20-29 age group recorded 16% (3) of injuries at the shoulder, but the wrist was the most common location for injury within this group representing 22% (4) of injuries. Interesting under 19s also reported 22% (4) of injuries at the wrist. Although more injuries were reported by younger athletes (<30 years of age) than those over 30 years of age, Figure 4.4.1.10 indicates injuries are common across all age groups and the shoulder is a frequent location of injury, especially in athletes aged over 30 years.

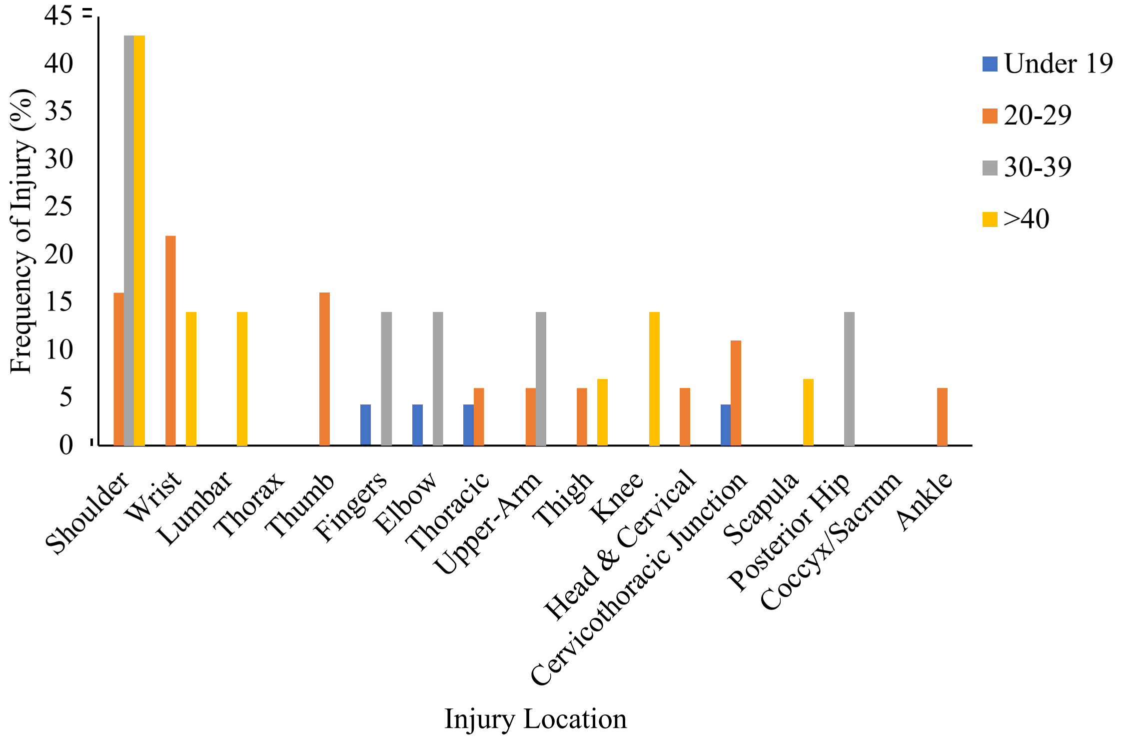


Figure 4.4.2.10: Frequency and location of injuries across age groups.

4.4.3 Gender '

When analysing with respect to sex over two thirds of injuries were recorded by male athletes, 69% (43) and only 31% (9) by females. The location of injuries recorded by males and females was considerably different (Figure 4.4.3.11). Males followed the trend of the general population and showed the shoulder to be the most frequent site of injury recording 37% (16) of injuries, 14% (6) of injuries in males were wrist injuries. The remaining sites recorded only a small number of injuries. In comparison females reported a higher frequency of injuries at the wrist with 26% (5) and only 16% (3) of injuries were recorded at the shoulder. Figure 4.4.10 shows injuries are common amongst male and female athletes; however, the location of injuries differs between sex.

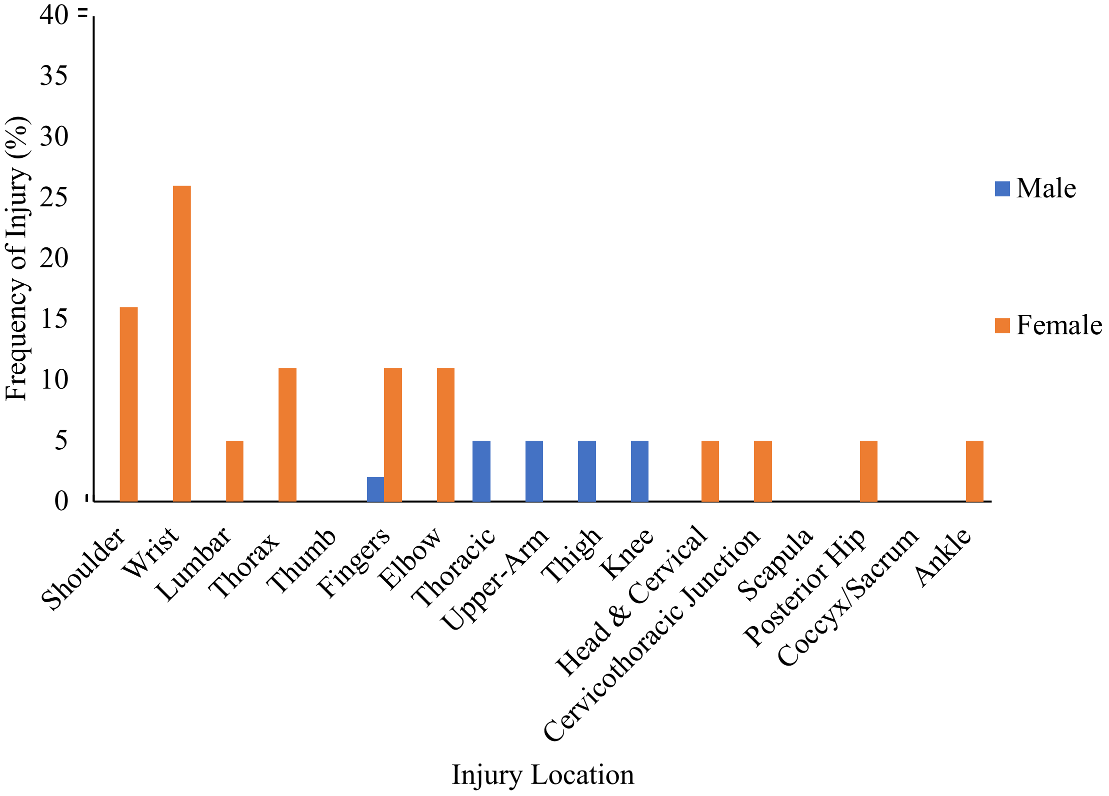


Figure 4.4.3.11: Frequency and location of injuries in male and female athletes.

4.4.4 Classification

Results from analysis of injury frequency and location according to athlete classification identified the shoulder was the most frequently injured location in all groups (Figure 4.4.4.12). Subsequently athletes classified as 3.0-3.5 and 4.0-5.0 recorded high rates of injury at the shoulder at 43% (6) and 27% (3) respectively. Whilst 1.0-1.5 classified athletes reported the lowest frequency of injuries at the shoulder; 23% (6), athletes at 2.0-2.5 classification recorded a higher rate at 36% (4). After the shoulder the wrist was the second most common location in all classification groups bar 3.0-3.5. It should be noted that 2 athletes within the 3.0-3.5 group had previous sustained major rotator cuff damage and thus injuries to the shoulder were expected. Assessment of injuries within classification suggests the shoulder is a frequent injury location across all classifications, but athletes classified between 2.0-3.5 reported higher frequencies of injury than 1.0-1.5 and 4.0-5.0 athletes. On top of injury assessments athlete demographics were also recorded (Table 4.4.4.8).

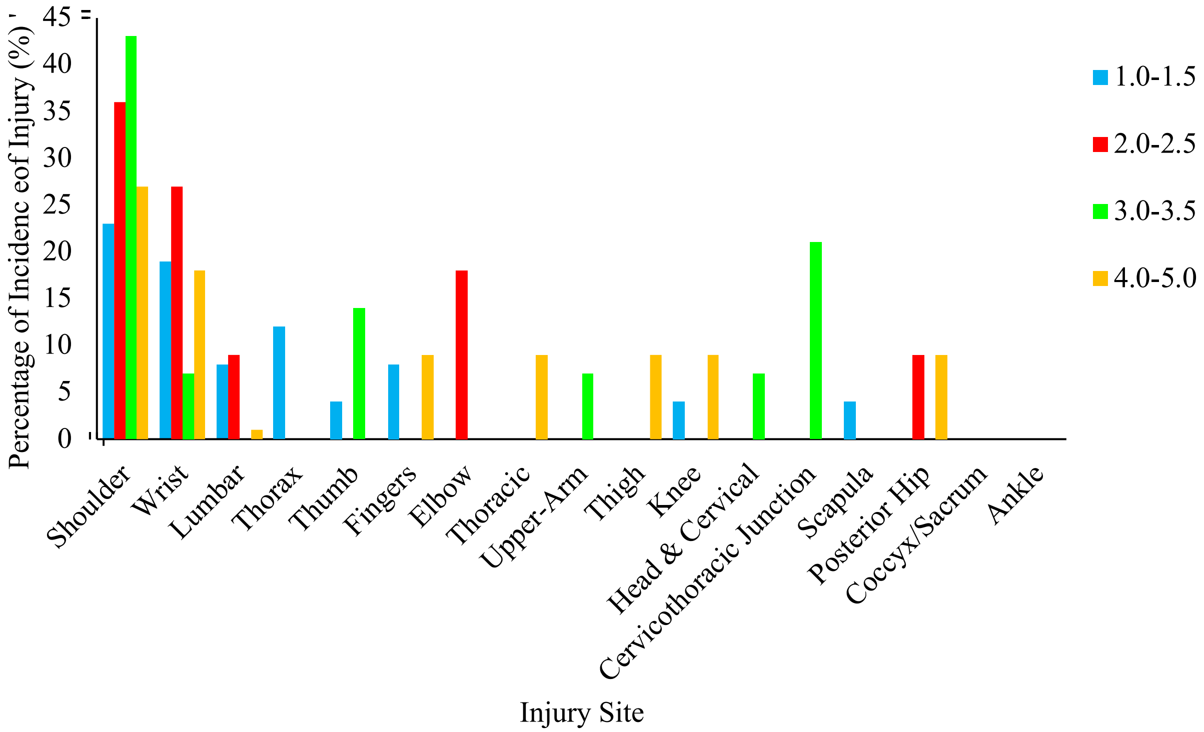


Figure 4.4.4.12: Frequency and location of injuries according to classification group.

Table 4.4.4.8: Average age according to classification groups and gender

Classification Group	Mean Age	Male	Female
1.0-1.5 (11)	28.0±11.6	32.3±14.3 (9)	20.5±3.5 (2)
2.0-2.5 (8)	27.8±13.0	30.2±15.8 (5)	23.7±7.4 (3)
3.0-3.5 (8)	24.9±9.1	28.8±9.2 (5)	18.0±3.6 (3)
4.0-5.0 (7)	29.4±15.3	32.0±16.8 (5)	23.0±12.7 (2)

Reporting injuries in accordance to WCB classification has not previously been reported. But the results of this current study show injuries sustained by athletes in each classification follows the general trend of injuries as shown in Figure 4.4.8, that the shoulder is the most frequently injured location.

4.4.5 Disability

Further to assessment of injuries in reference to athlete classification, athlete disabilities were also assessed (Figure 4.4.5.13). Over half, 52% (32) of the total injuries were recorded by athletes with SCIR, athletes with amputations and CP recorded 10% (6) and 11% (7) of total injuries and AB athletes reported 8% (5) of total injuries. The 'other' group reported 19% (20) of total recorded injuries. Following the general trend of results, the shoulder was the most frequently injured location amongst athletes with amputations recording 66% (4), CP 43% (3) and other disabilities 33% (4). The wrist reported the highest frequency rates in athletes with SCIR, 25% (8) and AB reported 40% (2) of injuries at the wrist. Overall, injuries are common amongst all disabilities with the shoulder and wrist being the most frequent locations to injury and different disabilities appear to predispose athletes to different injuries.

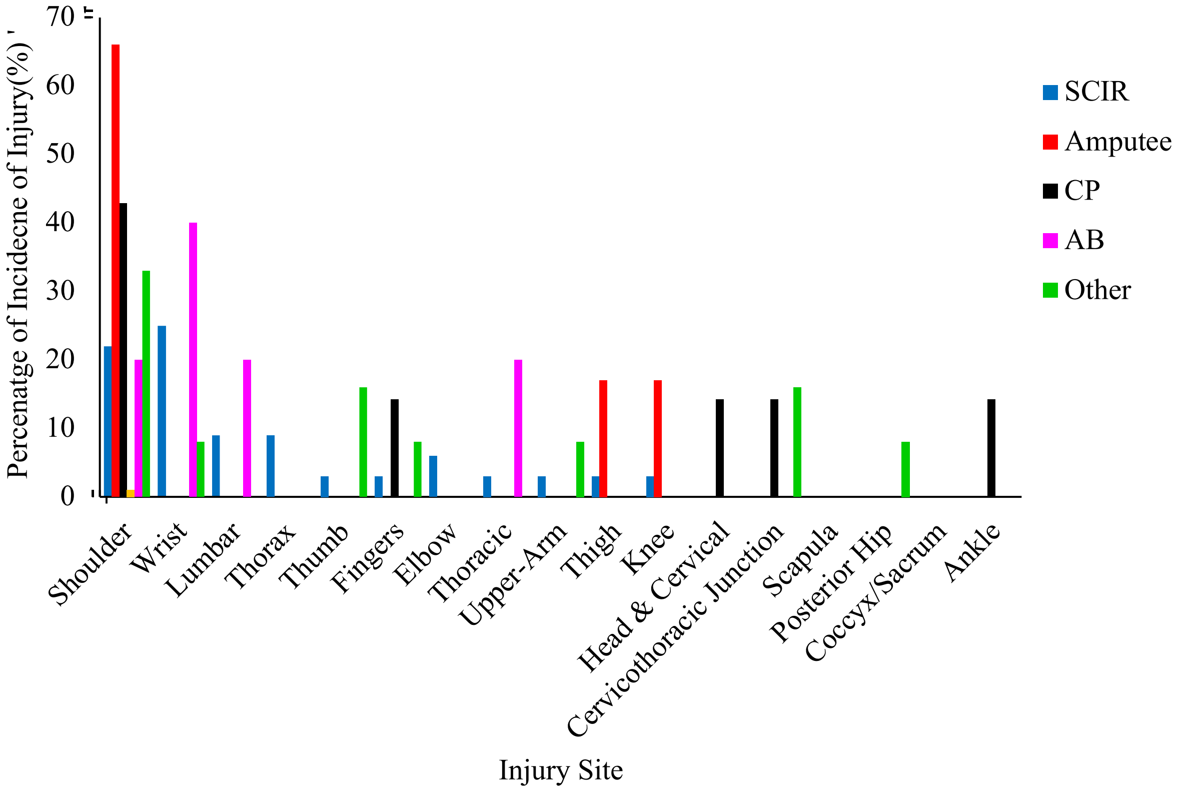


Figure 4.4.5.13: Frequency and location of injuries in relation to athlete disability.

Group demographic were recorded in Table 4.4.5.9 and whilst the degree and classification of athlete's disabilities was noted all athletes were grouped according to their disability. The group entitled 'Other' was compromised of numerous conditions and included athletes with Polio, Ehlers-Danlos Syndrome, idiopathic sensory peripheral neuropathy, Charcot-Marie-Tooth disease and Perthes disease, plus one disability that has not been labelled but was sustained from a road traffic accident leaving the individual with sever motor dysfunction. The lesion-level reported from athletes with SCIR ranged from T3-T12 with a mixture of complete and incomplete lesion. Of the four athletes with amputations one was unilateral above knee, one unilateral below knee, one bilateral below knee and one bilateral above knee. All athletes with CP were classified within the spasticity type, but as Figure 4.1.5 functional capacity greatly differed between athletes.

Table 4.4.5.9: Average age according to disability groups and gender. '

Disability Group	Mean Age	Male	Female
SCIR (15)	28.3±6.7	30.5±13.0 (11)	22.3±6.7 (4)
AMP (4)	34.5±15.7	41.3±9.5 (3)	14.0±0.0 (1)
CP (4)	20.8±2.1	19.0±0.0 (1)	21.3±2.1 (3)
AB (4)	26.8±14.7	31.0±14.7 (3)	14.0±0.0 (1)
Other (7)	26.1±11.5	25.2±12.3 (6)	32.0±0.0 (1)

4.4.6 Playing Standard

Athletes were finally analysed in reference to which British Wheelchair Basketball league they regularly participated in, with Table 4.4.6.10 summarising athlete demographics. Injury frequency and location assessment found almost half of total reported injuries came from athletes in division 1, 47% (29) (Figure 4.4.6.14). The lowest division (division 3) reported whilst 22% (14) of injuries, and 13% (8) and 15% (9) of total injuries were recorded from the premier division and division 2 respectively. The shoulder was the most frequently injured location in athletes from only two leagues, division 1 recorded 41% (12) and division 3 36% (5) of injuries at the shoulder. Although athletes in the premier division sustained shoulder injuries, premier division athletes recorded higher frequency rates at the wrist at 63% (5). In contrast athletes from division 2 did not report a single shoulder injury, the only group in the study to do so, they reported the thumb as the primary location of injury 33% (3) however two of these injuries were reported by the same individual and thus may skew results. Figure 4.4.6.14 demonstrates that injury frequency and location differ from each playing league and only division 1 and 3 athletes match the trends shown in previous groups and by Figure 4.4.8, therefore the standard at which each athlete plays at may contribute to injury frequency and location.

Table 4.4.6.10: Average age according to playing standard and gender '

Playing Standard	Mean Age	Male	Female
Premier (4)	33.3±14.7	38.3±13.1 (3)	18.0±0.0 (1)
Division 1 (15)	28.5±11.0	29.8±11.5 (12)	23.0±7.8 (3)
Division 2 (3)	23.3±2.5	23.5±3.5 (2)	23.0±0.0 (1)
Division 3 (10)	24.4±12.5	25.0±15.8 (6)	22.3±7.4 (4)

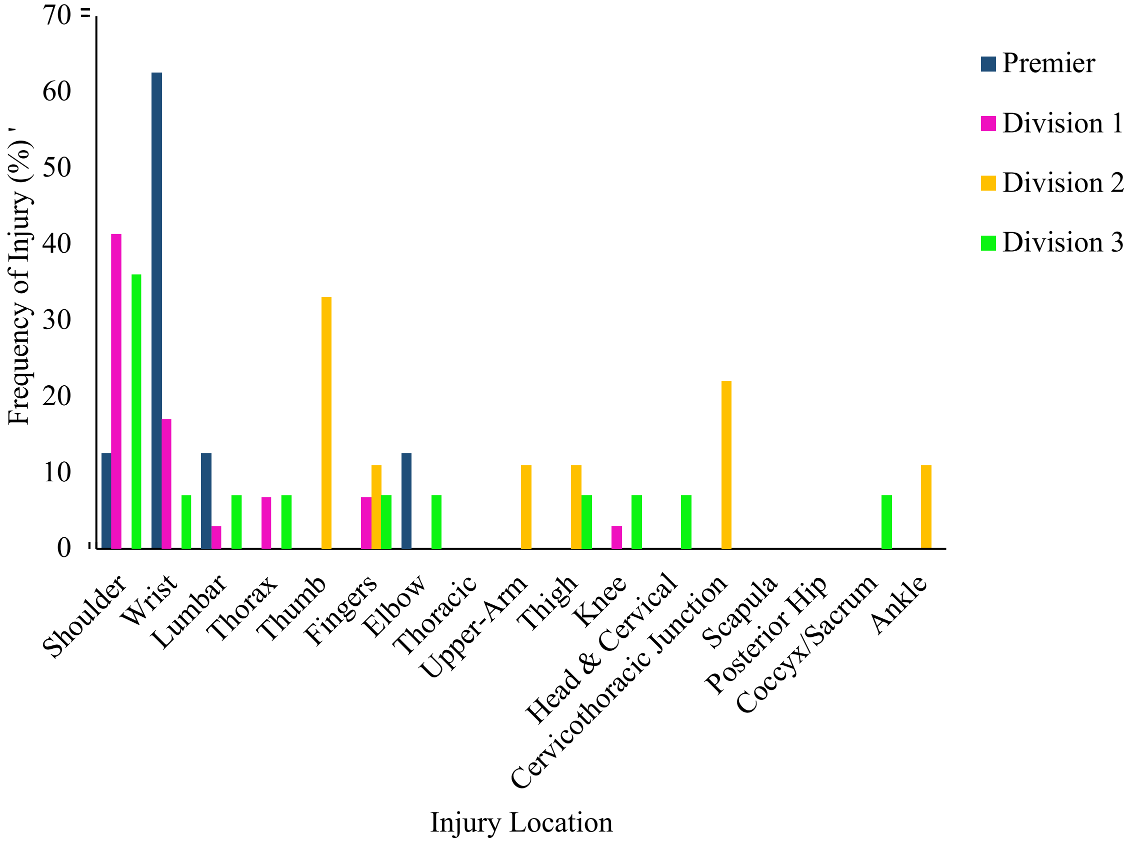


Figure 4.4.6.14: Frequency and location of injuries across British wheelchair basketball leagues

4.4.7 Summary

Results from the injury data collected have provided a greater understanding on injury frequency and location within WCB athletes compared to previous research (Table 2.2.1.3 and 2.3.2.4). Fundamentally, injuries are a common occurrence in WCB, and the shoulder is a prime location for injury across age, gender, athlete disability, classification and playing standard. However, other injury locations, such as the wrist, are prominent in WCB athletes and within some group exceed that of the shoulder. To aid understanding of injury frequency and location with different athlete populations Figures 4.4.7.15-19 have been created to summarise the frequency of different injury locations within different athlete populations. The benefit of using these flow charts is a WCB coach, medical professional or athlete can quickly identify common locations to injury in accordance to their age, gender, disability, classification and playing standard, and then aim to reduce these incidences by implementing injury reduction-based strategies.

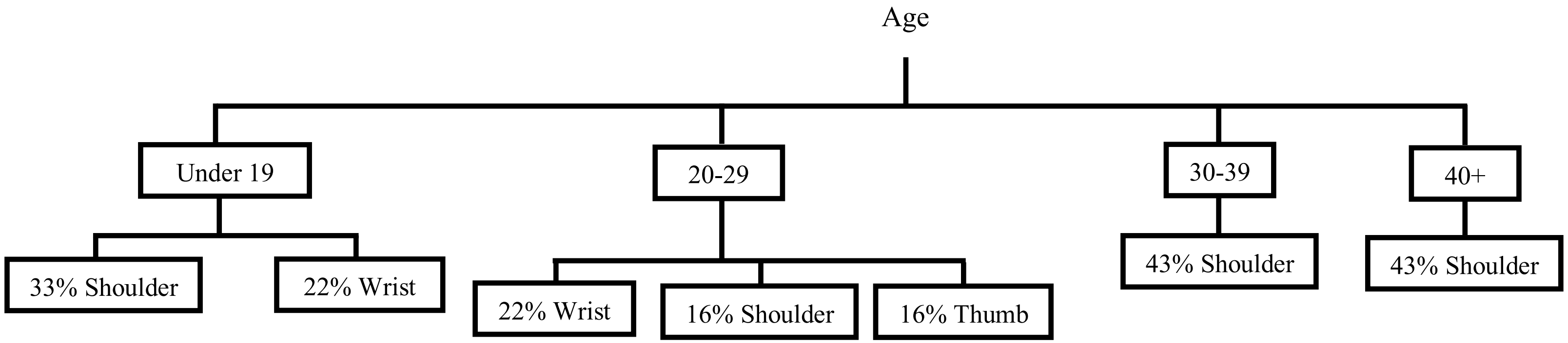


Figure 4.4.7.15: Summary of injury frequency and location according to age. '

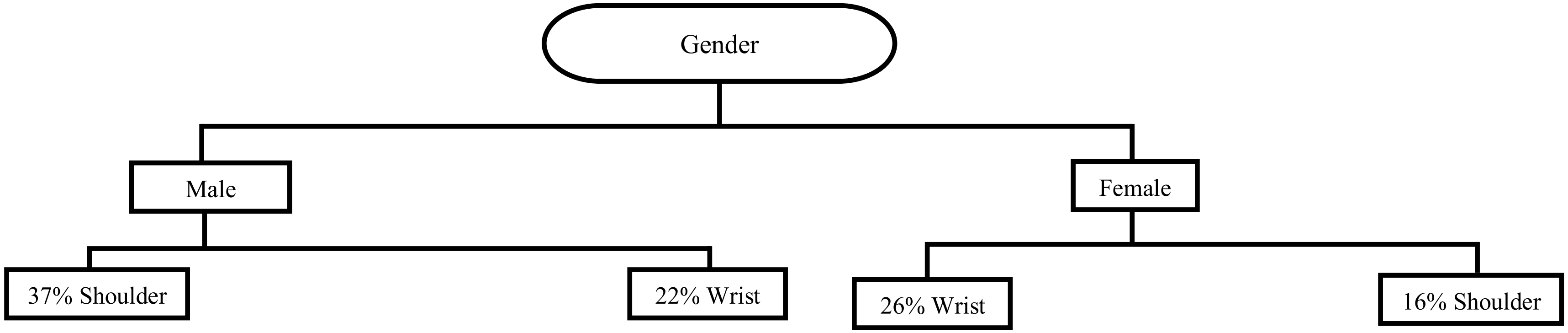


Figure 4.4.7.16: Summary of injury frequency and location according to gender.

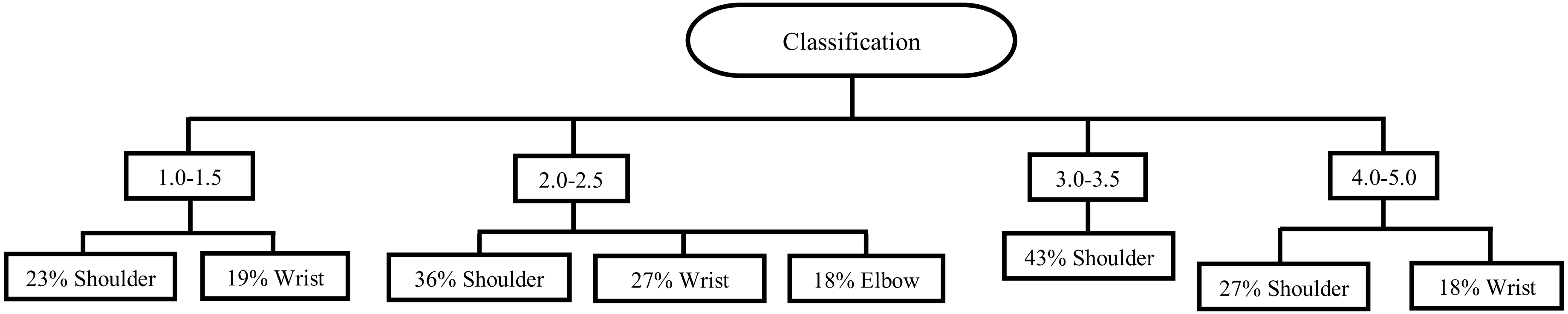


Figure 4.4.7.17: Summary of injury frequency and location according to athlete classification.

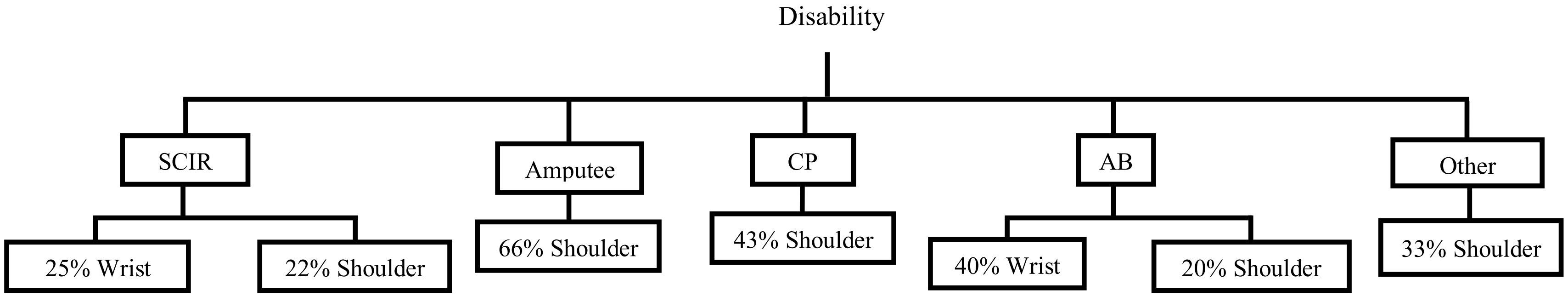


Figure 4.4.7.18: Summary of injury frequency and location according to athlete disability.

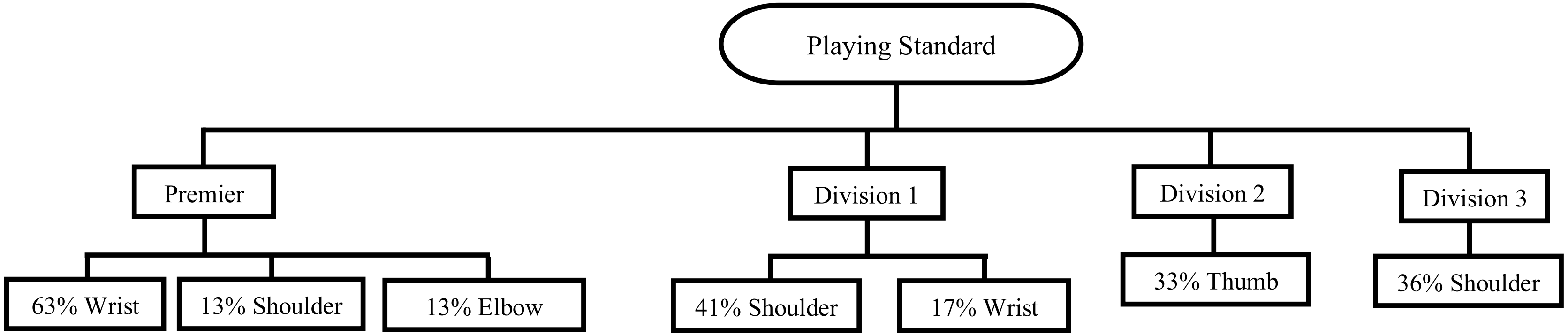


Figure 4.4.7.19: Summary of injury frequency and location according to playing standard. '

4.5 Relative Risk

Simply recording injury frequency and location does not determine whether a certain population is at increased predisposition to injury, this is calculated through RR. Therefore, in addition to the descriptive analysis of injury data, RR were calculated within gender, age, disabilities, classification and playing standard.

4.5.1 Age

As Figure 4.4.2.10 shows, injuries occurred across all age groups, but more injuries were reported in the under 19s age group as opposed to any other age group. However, no RR was found with the under 19 age group (0.77), yet athlete within 20-29, 30-39 and 40+ age group all recorded RR 1.0 (1.31, 1.01. and 1.01 respectively). The largest RR was seen within the 20-29 age group (1.32) and both 30-39 and 40+ athletes reported a RR of 1.01. RR data shows that athletes over the age of 19 years were at a greater risk of sustaining an injury compared to those under the age of 19, and athletes aged between 20-30 demonstrate the greatest risk.

4.5.2 Gender

The findings from Figure 4.4.2.11 clearly show a difference between both injury frequency and location between male and female athletes. When assessing RR of males against female athletes a RR of 0.93 was reported, but when female athletes were assessed against males a RR of 1.08. Although male athletes reported a greater frequency of injuries it appears females are more likely to get injured, but injuries in females are more likely to occur at the wrist (Figure 4.4.2.11).

4.5.3 Classification

Results from Figure 4.4.4.12 suggest athletes classified between 2.0-3.5 are more likely to sustain injuries than athletes classified as 1.0-1.5 and 4.0-5.0. Assessment of RR shows athletes classified from 2.0-5.0 display no RR to injury (<1.0), and athletes classified as 1.0-1.5 demonstrate an RR of 1.35. Although no RR was identified in 2.0-5.0 athletes both 2.0-2.5 (0.89) and 3.0-3.5 (0.89) groups reported a higher RR than 4.0-5.0 (0.84). Crucially these findings not only show 1.0-1.5 are at greater risk of sustaining an injury compared to other classification, but as classification decreases; in line with function (Table 1.1.1).

4.5.4 Disability

As a RR was found in athletes classified as 1.0-1.5, it is unsurprising that athletes with SCIR similarly reported a RR of 1.27 and reported RR in other disability groups was <1.0. Athletes with CP, amputees or AB reported an RR of 0.9 and athletes within the other disability group recorded a value of 0.84. Fundamentally these finding support results discussed in Table 2.3.2.4 that athletes with SCIR are likely to sustain injuries and when linked with classification RR data, it can be hypothesised that reduced function may contribute to the increase risk of injury.

4.5.5 Playing Standard

Assessments showed RR were found within athletes playing in the premier division (1.22), and in divisions 1 (1.05) and 2 (1.21). The greatest RR was seen in the premier and division 2 athletes at 1.22 and 1.21 respectively whilst division 1 athletes reported an RR of 1.05, no RR was found with division 3 athletes (0.77). From anecdotal observation there is a large difference in playing standard between each division, but it is clear from these results that as playing standard increases risk to injury increases. Existing research has suggested the reverse of these findings in that lower ability players are at a greater risk, whereas it is clear from this current study those at a higher standard as more susceptible to injury.

4.5.6 Summary

Analysis of RR data has shown a range of different populations being at increased predisposition to sustaining an injury. From these results, athletes over the age of 20 are more likely to sustain injuries with those aged between 20-29 displaying the greatest risk. Both athletes with SCIR and 1.0-1.5 classification are similarly at a greater risk, as are athletes playing at a higher standard. Results from this present study help to identify different athlete populations within WCB who are at a greater predisposition of sustaining an injury which in conjunction with Figures 4.4.7.15-19 can be used to understand exactly where these injuries will occur.

5.0 Discussion

The aim of this retrospective descriptive questionnaire-based study was to understand the injuries sustained by WCB athletes, identify injury frequency and location and begin to understand what factors predispose athletes to injury. Findings from this study have successfully highlighted injury frequency and location in WCB athletes, identifying the shoulder as the most frequently injured location. Furthermore, results have been able to identify athlete populations with an increased predisposition to injury, these populations include athletes aged between 20-29, who are female, classified as 1.0-1.5, are SCIR and play at a high standard. Overall the hypothesis of this study can be accepted, in that the shoulder is the most frequently injured location in WCB and predisposing factors exist within age, gender, classification, disability and playing standard. The following sections will discuss the results of this study in greater detail whilst also providing greater understanding to their meaning. Finally, recommendations to practice and future research will be made.

5.1 Demographics '

A total of 44% of the athletes within this study were reported as SCIR (Figure 4.1.3) which was, expected to be the largest disability group recorded as shown in previous literature (Table 2.2.1.3 and 2.3.2.4). In relation to classification, Figure 4.1.4 demonstrates low point athletes (1.0-2.5) represented the largest portion of the population at 56% (32%:1.0-1.5, 24%: 2.0-2.5). There is no published data displaying a WCB team's demographics as this is simply not the focus of research in WCB. Anecdotally, it is typical of a WCB team to have a large representation of athletes with SCIR and thus low point athletes (Figure 4.1.5). These athletes are deemed valuable, as fielding numerous low point athletes allows a WCB team to subsequently field multiple high point athletes whom have a greater functional capacity.

To the authors knowledge the present study, is the first study to record injury frequency and location in detail and the first to analyse injuries in relation to athlete age, gender, disability, classification and playing standard. Consequently, this study is the first to consider mechanisms behind WCB injuries as well as identifying predisposing factors to injury.

5.2 Injury Frequency and Location Overview

The shoulder is the most frequently injured location in WCB (Figure 4.4.8) and supports the findings of existing research (Table 2.2.1.3 and 2.3.2.4). However, the frequency of shoulder injuries differs between age groups, gender, classification, disability and playing standard. Critically, the reported injury trend from the present study follows a similar trend as reported by Willick et al (2013) (Figure 4.4.8) at the London 2012 Paralympic Games. Although Willick et al (2013) results are in reference to all sports at the Paralympic Games, it shows the reported injury frequency and location by WCB athletes is similar to those reported by elite Paralympic athletes.

The current data shows injuries are a common occurrence in WCB with athletes reporting 62 injuries across 17 different locations. Of the reported injury locations, the shoulder was the most prominent location recording 31% (19) of total injuries. Besides the shoulder, a high number of injuries were reported at the wrist, representing 18% (11) of total recorded injuries. The results from the present study were expected, due to the nature of WCB and the role of the shoulder through WCB skills, shoulder injuries were expected to be high. However, the high frequency of wrist injuries was unexpected, but not surprising, as the nature of WCB heavily relies on the wrist and shoulder to execute skills.

Unlike existing research, the time at which injuries occurred during a WCB season was assessed to determine if injury frequency differed at any time point during a season. However, no significant differences were found suggesting injuries occur at a steady rate throughout a season.

From the data collected overuse was reported as the most common mechanism to injury, yet it is unclear if this is in reference to training volume, overuse of a movement or general fatigue. Although athletes within the present study recorded low to moderate levels of fatigue, 4.4±2.2 and whilst athletes felt they recovered well between session and met the demands of WCB, fatigue is a factor which may have contributed in the development of injuries and requires further investigation.

5.2.1 Age

The average age of the population was 27.5±11.8 years, and although injury location did not greatly differ across all age groups (under 19s - >40 years), injury frequency did. Wrist injuries were more prominent amongst athletes under the age of 29, and shoulder injuries in those over 30. Unsurprisingly athletes showed an increased predisposition to injury as age increased, but athletes aged between 20-

29 showed the greatest predisposition to injury. Fundamentally, these findings support existing research from Willick et al (2013) at the London 2012 Paralympic games who found a similar age group (26-34) reporting higher injury rates and younger athletes reporting the lowest rates.

While athletes aged between 20-29 years were found to be the most susceptible to injury, it is unlikely that the degenerative nature of aging is the cause for the increased predisposition. Instead, overuse can maybe explain the increased predisposition, as this was the most commonly reported mechanism of injury throughout this present study (Figure 4.4.1.9). A factor to consider in relation to overuse is the amount of wheelchair experience athletes possess, as the nature of wheelchair use may increase loading into the upper quadrant and contribute to the development of injuries (Subbarao *et al.,* 1995). Thus, athletes with less wheelchair experience may be more prone to injury and may explain the high injury predisposition in athletes aged 20-29 years as younger athletes would typically have less wheelchair experience than older athletes. The overall wheelchair experience recorded in the present study was 16.5±24.8 years which demonstrates the vast difference in wheelchair use experienced. Evidence from the present study shows as athletes age their predisposition to injury increases, and the greatest predisposition to injury is found in athletes aged between 20-29 years.

5.2.2 Gender

Results from Figure 4.4.3.11 show differences between injury locations across male and female athletes, but the injury trend reported by male athletes closely resemble the general injury trend of the study (Figure 4.4.8). Female athlete reported the most injuries at the wrist; recording 26% (5) of injuries, whilst males recorded the shoulder as the most frequently injured site; representing 37% (16) of injuries. However, there is little difference between injury frequency as a whole between gender, a finding supported by existing research that found only minor differences in injury rates between males ' and females at the London 2012 Paralympic Games (Willick *et al.,* 2013).

In contrast assessment of RR demonstrated female athletes were at a greater predisposition to injury compared to males (1.08). When analysing injury frequency and location in conjunction with RR the present study would suggest females are more likely to sustain injuries at the wrist. However, exploration of existing research provides no understandings as to why females display an increased injury predisposition neither does it suggest why the wrist was the most frequently injured location. One such mechanism maybe a result of the athletes' disabilities, of which female athletes in this present study showed a higher representation to SCIR. Results from Figure 4.4.7.15 show athletes with SCIR reported marginally more wrist injuries than shoulder, and subsequently display a greater predisposition to injury (1.27), thus athletes with SCIR are more likely to sustain wrist injuries. Equally female athletes were younger in age, 21.3±6.4 years compared to males, 30.1±12.7 years, and RR assessment has shown athletes aged between 20-29 years to display the greatest predisposition to injury; an age range female athletes fall between. Therefore, the difference in injury location and RR between males and females may be a result of numerous factors such as age and disability and not solely from gender, thus more research needs to be conducted in this area to provide clarity.

5.2.3 Classification

The assessment of injury frequency and location in accordance to WCB classification is novel to this present study, with existing research primarily focuses on how classification effects performance (Molik *et al.,* 2010 and Yanci *et al.,* 2014). Injury frequency and location reports follow the expected trend, with shoulder injuries being recorded as the most frequent location across all classifications followed by the wrist (Figure 4.4.4.12). From the findings of this present study athletes classified from

2.0-3.5 appear to report more injuries than other classifications, however assessment of RR shows athletes with a 1.0-1.5 classification present with the greatest injury risk (1.35). Consequently, as athlete classification increases, RR decreases, suggesting as the greater the loss in functional capability the greater the injury predisposition.

Research assessing trunk stability in athletes with disabilities has found similar responses to that of this present study, where athletes with reduced trunk stability had greater injury predisposition (Table 2.3.2.4). Any reduction in trunk stability will affect an athlete's ability to avoid collisions, a study assessing injuries in wheelchair fencing found those with poor trunk control to have higher injury incidence as they could not avoid collisions (Chung *et al.,* 2012). The same mechanism can be applied to WCB, as athlete with classification ≤2.5 will present with reduced trunk stability and will not have the same movement control over the wheelchair as high classification athletes (≥3.0), therefore will not be able to avoid collisions that may lead to injury (Altmann *et al.,* 2015). Similarly, reduced trunk stability has been linked to the development of many shoulder injuries and is equally important to rehabilitation (Kibler *et al.,* 2006, Jaggi and Lambert, 2010 and Radwan *et al.,* 2014). As a result, an athlete's trunk stability is an integral factor to predisposition to injury, with greater losses of trunk stability and ultimately functional capability increasing athlete predisposition.

Research has also shown wheelchair propulsion cycles to be different between classification groups. Low point athletes (1.0-2.5) who sit lower in their wheelchair push for approximately 50% of the propulsion cycle and recover for 50%, compared to high point athlete (3.0-5.0) who push for 30% and recover for 70% of the cycle (Wei *et al.,* 2003). The 30:70 ratio seen in high point athletes is the expected cycle ratio, whereas the 50:50 ratio in low point players may increase demand to the shoulder through increased propulsion time and reduced recovery time, thereby increasing injury predisposition to the shoulder.

It is evident that as athlete classification decreases (<2.5) the predisposition to injury increases. However, the location in which injuries are sustained appears to remain constant across all classifications with the shoulder and wrist being the most frequently injured locations.

5.2.4 Disability

As discussed, previous research has already been conducted assessing injuries in relation to an individual's disability, finding athletes with high lesion-level SCIR to be more susceptible to shoulder pain (Table 2.3.2.4). Results from this present study have shown athletes with SCIR demonstrate a greater predisposition to injury compared to other disability groups. However, when assessing injury frequency and location athletes with SCIR do not dominate any of the injury sites and are one of the few population groups where the shoulder is not the prime injury location instead reporting a greater frequency at the wrist, contradicting existing research. The increased frequency of wrist injuries in SCIR athletes may simply be a result of habitual wheelchair use. As athletes with SCIR are dependent on wheelchair use for mobility purpose its continued use could act as a mechanism for injury. The nature of wheelchair propulsion applies repeated trauma to the wrist in patterns of wrist flexion, extension, ulna and radial deviation (Pentland and Twomey, 1991, Veeger *et al.,* 1998 and Wei *et al.,* 2003). Wheelchair propulsion in WCB greater (1.48m/s) than normal day to day propulsion (0.93m/s), thus a faster pace may increase the trauma experienced at the wrist (Hatchett *et al.,* 2009 and Sporner *et al.,* 2009). This mechanism may begin to explain the increased frequency of wrist injuries in athletes with SCIR.

Although shoulder injuries were not the most prominent injury site in athletes with SCIR they still represented 22% (7) of injuries. The nature of SCIR may provide an understanding to the presence of shoulder injuries. Athletes with SCIR present with a loss of trunk stability, and the higher the lesion-level the greater the loss (Santos *et al.,* 2016). As discussed previously reductions in trunk stability has implications in the development of shoulder injuries. Therefore, athletes with SCIR are at increased predisposition to injury due to their loss of trunk stability resulting from their disability. Crucially existing research supports this hypothesis as athletes with reduced trunk function have seen a higher prevalence to shoulder pain (Yildirim *et al.,* 2010). The results from this present study suggest it is important to understand the functional limitations of athlete's disabilities, as these limitations can affect injury predisposition.

In relation to athletes with CP, they reported 43% (3) of injuries at the shoulder and few injuries were reported at other locations (Figure 4.4.5.13). As Figure 4.1.5 shows some athletes with CP can experience losses in trunk stability similar to that of athletes with SCIR, and thus may experience increased predisposition to shoulder injuries as a result of this loss as discussed above. Equally, the nature of CP results in the occurrence of muscular contractures, which severely limits range of motion, in turn affecting performance and daily function (Nicholson *et al.,* 2001, Colver *et al.,* 2014). Although no athlete in this present study directly complained of contractures there were numerous complaints of muscular 'stiffness' which could be attributed to contracture. Again, these results support the basis that it is crucial to understand the limitations of athlete's disabilities.

The highest reported injury frequency was recorded at the shoulder by athletes with amputations. It should be noted that two of these athletes previously suffered from severe rotator cuff injuries, one full thickness tear and one unknown injury the result of a bomb explosion. The chance of re-injury following a severe rotator cuff-injury is quite high and as the rotator cuff has a key dynamic role in the shoulder it can lead to injuries or complications to other structures around the shoulder (Yamamoto *et al.,* 2010, and Gerber *et al.,* 2000). Therefore, whilst it is important to understand athletes' disabilities it is equally important to note injury history.

Although WCB teams are more concerned with classification over athlete disability the authors felt it was important to still assess injuries within disability. An athlete's disability directs which classification groups they representation however athletes within the same classification group do not present with the same functional limitations, this is determined by their disability. For instance, athletes with CP can present with the same limitations as SCIR to classify them as 1.0-1.5, but athletes CP have a greater capacity to improve their function that athletes with SCIR do not. Therefore, this reinforces the belief that it is important to understand and athlete's disability and what functional limitations it presents.

5.2.5 Playing Standard

Across all athlete playing standards the wrist recorded the highest rate of injuries compared to other locations across all groups (Figure 4.4.6.14). Despite this spike in reported wrist injuries the injury trend follows that of the present study (Figure 4.4.8) recording shoulder and wrist injuries as the most frequently inured locations. Although the shoulder did not record the highest rate of injuries, overall it was the most frequently injured location (Figure 4.4.6.14).

In relation to injury predisposition existing research suggests nonathletes to be at a greater predisposition than athletes (Table 2.3.2.4). The findings from the present study contradict existing research by stating injury predisposition increased with playing standard, with athlete competing in the premier division recording the highest risk and those in division 3 the lowest (see section 4.5.5).

Whilst all participants in this present study were athletes the standard at which they participated differed from those representing their country to athletes will less than 6 months WCB experience. However, it is important to note the shoulder and wrist remain as the most frequent location of injuries for the cast majority of athletes.

Anecdotally there is significant difference in the playing standard between each of the divisions and thus a greater physical demand on athletes is seen. With this increase in demand athletes would typically increase training volume to ensure they are fit enough to play. Dramatic increases in training volume, or volumes that are deemed to high can increase an athlete's predisposition to injury (Gabbett, 2018). In relation to this present study the average number of weeks training per year across was recorded at 40.0±17.2, with approximately 2.3±1.5 training sessions per week, lasting a duration of 5.5±3.5 hours. It is unknown whether athletes in the present saw dramatic increases in training volume throughout the 12-month testing period. However, findings from this study show athletes at a higher playing standard are at a greater predisposition to injury, and as existing research shows training volume to be a predisposing factor to injury is should be a parameter carefully monitored by WCB teams in order to reduce injury predisposition.

5.3 Trustworthiness

By design qualitative research is subjective and although researchers aim to produce accurate reliable and valid results, the nature of this design means studies lack numerical justification. As a result, efforts have been made to discuss the trustworthiness of qualitative research to determine accuracy, reliability and validity. Shenton (2004) discusses strategies to determine the trustworthiness of qualitative research by analysing its credibility (in preference to internal validity), transferability (in preference to external validity), dependability (in preference to reliability) and confirmability (in preference to objectivity). The following section will discuss these parameters in relation to this present study to assess its trustworthiness.

5.3.1 Credibility

Credibility is perhaps the most important factor in establishing trustworthiness and relates to whether the study's findings are consistent with reality (Shenton, 2004). Firstly, it is described that studies should follow procedures from previous comparative successful research (Shenton, 2004). The absence of comparable research is the primary cause for conducting the present study. However, the study design was selected based on existing literature (Table 2.2.1.3 and 2.3.2.4) and is a retrospective descriptive questionnaire-based design. Existing literature provided no detail on questionnaires used to assess global injury frequency and location, as a result the present study was forced to create its own questionnaire. The design of this questionnaire was based on the aims and objectives of the study and was piloted to ensure reliability and validity.

Another factor to ensure credibility is for researchers to familiarise themselves with organisations and participants to build a degree of trust (Shenton, 2004). The researcher within the present study had been immersed in the culture of WCB spending 3 years leading the medical team at the Coventry Wheelchair Basketball Academy, who themselves represented a large portion of the sample size. Furthermore, as the Coventry Wheelchair Basketball Academy is one of the most prominent WCB teams in the United Kingdom it has built multiple working relations with WCB teams across the country and thus the researcher was able to use these relationships to make contact with participants. The relationships formed from early familiarisation enabled a small group of athletes to be included in a pilot group to assess the newly developed questionnaires (Appendix 6 and 7). This process would not have been possible if trust had not been established between the researcher and participating athletes. The researcher's familiarity and experience within WCB provided a background knowledge ' to the nature and demands of the sport that helped determine a suitable hypothesis and provides a greater understanding to the results.

Whilst the present study only conducted one assessment in the form of a questionnaire, the researcher was present while athletes completed theses questionnaires. Although, this is not an assessment, it allowed the researcher and athletes to communicate in which the former could answer any questions they may have had about their injuries and crucially the researchers could gain more detail surrounding these injuries aiding the overall findings. Furthermore, as many of the athlete were affiliated to the Coventry Wheelchair Basketball Academy the researcher already had a record of injuries for athletes as this was the club in which the researcher worked at. It is important to note the researcher was on hand to serve as a contact to the athletes and did not manipulate athletes into completing the questionnaires to support the studies hypothesis. Furthermore, this process also enabled the researcher to question reported injuries to ensure information was correct.

Before athletes committed to participation in the study it was made clear that the results athletes reported would have no impact on them or impact their WCB participation. If participants feel pressured into completing the assessment or if they feel their results may negatively affect their WCB participation, then reported results may be dishonest. This is supported by evidence suggesting athletes underreport concussions as they do not wish to miss any game time (Meier *et al.,* 2005). Thus, to produce accurate, reliable, valid and credible results an environment in which athlete felt safe and comfortable was created.

5.3.2 Transferability '

The results from the present directly relate to a WCB population and are not widely transferable to non-WCB populations. However, results from this present study can be widely transferred within different WCB populations. As assessments were made across age groups, gender, classification, disability and playing standard the results can be interpreted within these WCB populations. Arguably as this present study is only concerned with the WCB population results do not need to be widely transferrable as they are specific to a certain population. As long as findings can be transferred into WCB then the study is deemed to demonstrate suitable transferability, and as this study was carried out in a WCB environment the results are transferable.

5.3.3 Dependability

In essence the dependability of qualitative research is an issue of reliability in that if the study was repeated in same manner similar results should be obtained (Shenton, 2004). Fundamentally, explicit details regarding all study related procedures should be provided from initial reviews to methodology and data analysis to enable easily replication. Methodological procedures have been displayed in Figure 3.0.2 to show the step by step process taken by this present study in selecting and executing a suitable methodology. Equally details were also provided on how results were assessed with Equation 1 and Table 3.6.5 displaying how RR were calculated. Furthermore, unlike existing research examples of the questionnaires used within this study have been provided in Appendix 6-9 to further aid dependability. However, it is the belief of the researchers from this present study that clear details have been provided throughout to enable future research to easily replicate it.

5.3.4 Confirmability

It is vital that any recorded results are reported from the experiences of the participants and not from preferences or bias from the researchers (Shenton, 2004). Although this present study gave a hypothesis on expected results as no successful research had previously been conducted the hypothesis was based on limited research and from the researchers own knowledge of WCB. Therefore, to ensure results demonstrated confirmability the researcher did not interfere with data collection nor were athlete made aware of the study hypothesis. Although the researcher was present upon data collection this was merely to answer any questions athletes had to and guarantee the questionnaires were completed correctly and honestly. Furthermore, details have been provided on how the methodology was conducted, the data assessed and what questionnaires were used to enable dependability which in turn will affect confirmability.

5.3.5 Summary

As a lack of comparable research is available surrounding injuries in WCB it was imperative the present study set a standard for future injury research within WCB. Therefore, as discussed efforts were made to ensure the present study demonstrates creditability, transferability, dependability and confirmability, overall demonstrating the present is trustworthy in its report on injury frequency and location in WCB.

5.4 Implications to Practice '

The findings from the study will aim to educate WCB populations and practitioners on the frequency and location of injuries. Whilst also providing information potential predisposing factors to injury, which in turn can be used to reduce overall injury frequency.

5.4.1 Injury Frequency and Location '

The primary aims and objectives of the present study was to evaluate injuries within WCB and identify frequency and location of injuries. These aims and objectives have been achieved by identifying the shoulder as the most frequently injured location in WCB (Figure 4.4.8). Injury frequency and location was also assessed in accordance to athlete age, gender, classification, disability and playing standard, being the first study to do so. Results indicated that although injury frequency and location across all groups followed the general injury trend (Figure 4.4.8) differences were exhibited within each group. To summarise these differences in injury frequency flow-charts were created (Figures 4.4.7.15-19) to clearly depict the most frequently injury locations in accordance to these groups. When presented with an athlete, practitioners can reference these flow charts to determine the most probable location for injuries for that athlete based upon their age, gender, classification, disability and playing standard. For example, when presented with a male athlete Figure 4.4.7.16 shows the athlete is likely to sustain an injury at the shoulder, therefore informed decisions can be made with the aim of reducing the risk of sustaining an injury to the shoulder.

In essence the identification of injury frequency and location informs WCB teams on where injuries are likely to occur and what different athlete populations will report. From this information teams can begin to understand how injuries may affect their athletes and thus introduce strategies designed to reduce injury frequency and location.

5.4.2 Predisposing Factors to Injury

A secondary objective of this present study was to highlight predisposing factors to injury. This is an integral assessment in relation to injury research as merely identifying what injuries occur or what injuries populations will record does not identify populations at greater injury predisposition. Analysis of existing literature had begun to highlight such factors (Table 2.3.2.4), but research has been inconclusive in detailing what factors may affect injury predisposition.

Assessments within this present study found certain populations amongst assessed groups demonstrated a greater predisposition to injury. Athletes aged over 20 presented with a RR >1.0 and those aged between 20-29 years displayed the greatest injury. Female athletes were also identified as having a greater predisposition to injury, as were athletes classified as 1.0-1.5 or persons with SCIR. Finally, as athlete playing standard increased their predisposition to injury similarly increased. From this assessment WCB teams can determine which athletes are a greater predisposition to injury. When analysing all RR data the greatest injury predisposition is found in a female athlete aged between 20-29, classified as 1.0-1.5 having a SCIR disability and playing in the premier division.

By correlating RR results with injury frequency and location reports it can be determined where these injuries are likely to occur. For instance, in the example of a female athlete aged between 20-29, classified as 1.0-1.5 having a SCIR disability and playing in the premier division, they are more likely to sustain an injury at the wrist than any other location (Figure 4.4.7.15-19). Ultimately, this present study provides critical information that enables WCB teams to implement suitable and specific injury reduction strategies based on athlete predisposition and reported injury frequency and location.

5.4.3 Recommendations

Several recommendations to practice can be made from the findings of this present study. Firstly, the results provide insight into general injury frequency and location in WCB athletes and within different population groups. Additionally, assessment of predisposing factors highlights populations within these groups with increased predisposition to injury. These results can be used to predict injuries within WCB, and thus suitable injury reduction strategies can be implemented. As this present did not conduct assessments into how predisposing factors to injury effect an athlete's injury predisposition no advice can be given on which injury reduction strategies should be prescribed. However, the present study does identify populations at a greater predisposition to injury, thus injury suitable reduction strategies should be introduced to reduce athlete injury predisposition.

It has become evident from analysis of existing literature and from the results of the present study that it is imperative to understand the functional limitations of the athlete. In both assessment of athlete classification and disability it was discovered that those with decreased functional capacity have a greater predisposition to injury at the shoulder. The common factor in athletes with reduced function is the loss of trunk stability which is a known contributing factor to multiple shoulder injuries (Kibler *et al.,* 2006, Jaggi and Lambert, 2010 and Radwan *et al.,* 2014). However, simply prescribing a programme to increase trunk stability will not benefit the athlete unless the athlete's function is considered. For example, athletes with CP are more likely to see improvements in trunk stability than athletes with SCIR as a result of the nature of the disability. Consequently, it is the recommendation of this study for WCB teams and relevant healthcare professional to understand the limitations and needs of each athlete in order to effectively reduce injury predisposition.

6.0 Limitations

One of the main themes of the literature review was the use of injury definitions, with the review concluding any definition used must be detailed and clear in what constitutes an injury. The definition used in this present study is provided by Willick et al (2013) and was selected based on the level and clarity of detail provided. However, as definitions differ between injury studies (Table 2.2.1.3) what this present study classifies as an injury may differ from other studies and vice versa, thus vastly different reports may be produced. Equally it is difficult to analyse findings from comparable research that use difference definitions. Although the definition in this present study is believed to be a suitable definition until a consensus of an injury definition is made, the use of definitions will remain a confounding issue for injury-based research.

To record injuries the present study followed the design of previous research (Table 2.2.1.3 and 2.3.2.4) and selected a retrospective questionnaire-based design. As the present study relied on athletes to recall any injuries, they had sustained in the last 12 months, human error may have occurred, and some injuries may have been misreported or forgotten. This in turn may have affected the overall reporting on injury frequency and location, but this error cannot be avoided in this type of study design and it is uncertain how much of an effect is has overall results.

The process of recording injuries was done through the use of questionnaires. Although previous studies similarly used questionnaire, few details existed surrounding them and of the few studies that did quote what questionnaires were used they were deemed unsuitable for the present study. Therefore, specific questionnaires were designed and created for the purpose of this present study (Appendix 6 and 7). These questionnaires were piloted to a small group of athletes who provided feedback to make the questionnaire more user friendly (details discussed in section 3.4), which in turn provides a degree of reliability, validity and trustworthiness. Additionally, the researcher was on hand to provide support to athletes whilst completing the questionnaire to ensure the process was done correctly. However, researcher should be conducted in assessing the overall reliability and validity of the questionnaires used in this present study.

Furthermore, no additional assessment was conducted outside of the questionnaires. This was deemed suitable for this present study as it was aimed at establishing general injury frequency and location in WCB, not diagnosing specific injuries. As the diagnostic validity of physical assessment in the upper-limb is questionable particularly at the shoulder, a questionnaire assessment was considered sufficient and provided enough detail for the present study. However, without a physical assessment the accuracy of reported injuries is put into question. An athlete may report an injury at one location but upon investigation the injury may be a result of an injury at a completely separate location. As a result, injuries would still be recorded but the location of the injury misreported, effecting the interpretation of results. Although the researcher was present at the time of questionnaire completion, they did not conduct any physical assessments, though questions may have been asked regarding their injuries to ensure questionnaires were completed correctly.

The overall sample size of the present study is 34 participants and is considered small. Although some similar studies much larger sample sizes (Table 2.2.1.3 and 2.3.2.4) some report on only slightly larger sample. The small size effects results, as a much larger sample may have recorded different proportions injuries, whilst the shoulder would still be expected to the most frequently injured location other locations may increase in frequency effecting the overall interpretation of results. Furthermore, a novelty of this present study was the assessment of injury frequency and location in accordance to age, gender, classification, disability and playing standard, but the small sample means small numbers were represented in these groups ultimately questioning the validity of the findings.

Finally, there is limited evidence to support the claims of this present study. Whilst this study has been able to establish injury frequency and location in WCB and highlight populations at greater injury predisposition little to no evidence existing exploring the mechanisms behind these results. This research is essential in understanding how and why injuries occur and provides key detail in reducing injury frequency, and without this understanding unsupported hypothesis are made.

7.0 Future Research '

As this is a relatively unexplored area of WCB research there are numerous directions for future research. Firstly, a large-scale prospective study can then be conducted assessing injuries as they occur during a WCB season. From this it can be determined when injuries are likely to occur and at what rate. Furthermore, including assessments of training volume and fatigue would be advisable as these are areas that can influence injury frequency (Gabbett, 2016). A simple record of training volume coupled with athlete session rate of perceived exertion will begin to provide an understanding on the role of fatigue and training volume in relation to injuries.

To assess injuries on a wider scale the use of an injury database can be implemented. Injury databases have already been put in place by the Rugby Football Union, Olympic and Paralympic Games and by the National Basketball Association (Drakos *et al.,* 2010 and Willick *et al.,* 2013). In these cases, healthcare practitioners input their own athlete injury data to record injury incidence on mass. Whilst assessments would not be standardised recording specific injuries on mass provides a great deal of information surrounding injuries and rates of injury that WCB would find useful.

A longitudinal assessment of predisposing factors to injury would be advised with research looking at not just identifying these factors but highlight mechanisms behind them. Therefore, it is essential to conduct research in this area on both injured and non-injured personal to assess the value of the predisposing factors. Findings from this study have highlight populations at greater injury predisposing, therefore targeting research around the mechanisms behind this increased predisposition can aid in identifying methods to reduce overall predisposition.

A recommendation of this present study is the introduction of injury reduction-based strategies to reduce overall injury frequency. In order for these strategies to be implemented the above research must first be conducted, to understand the mechanisms behind injury predisposition and determine ' what factors can be influenced by reduction strategies. The selected strategy needs to be implemented and assessed for effectiveness in reducing overall injury frequency.

Finally, outside of WCB, research should be conducted in finding a consensus for an injury definition. Whilst there is no consensus, studies will continue to use multiple definitions and report on vastly different findings influencing overall reliability and validity. This present study has highlight what a good injury definition should constitute of and thus steps should be made from this to assess current injury definitions used in literature and provide a consensually agreed definition to be used in future injury-based research.

8.0 Conclusion

This present study was the first to comprehensively assess the frequency and location of injuries in WCB, and the first to assess injuries in relation to athlete populations. It is also the first to highlight potential predisposing factors to injury. The shoulder has been reported as the most frequently injured location within WCB, recording 31% of injuries, although rates differ across athlete age, gender, classification, disability and playing standard. Athletes aged 20-29 years, females, 1.0-1.5-point players, person with SCIR and athletes participating in the premier division all displaying the greatest predisposition to injury. The novel findings of this study provide recommendations to practitioner's regarding injuries and populations who are at a greater predisposition to injury. Fundamentally, it is important to understand athletes' functional limitations as findings has shown those with reduced functional capacity possess the greatest injury predisposition. Additionally, this study has set a platform for future research which can further examine injuries and predisposing factors in WCB athletes, with the ultimate aim of reducing the rate of injuries.

9.0 Appendix '

Appendix 1: Certificate of Ethical Approval '

Coventry University

Certificate of Ethical Approval

Applicant:

Matthew Williams

Project Title:

Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

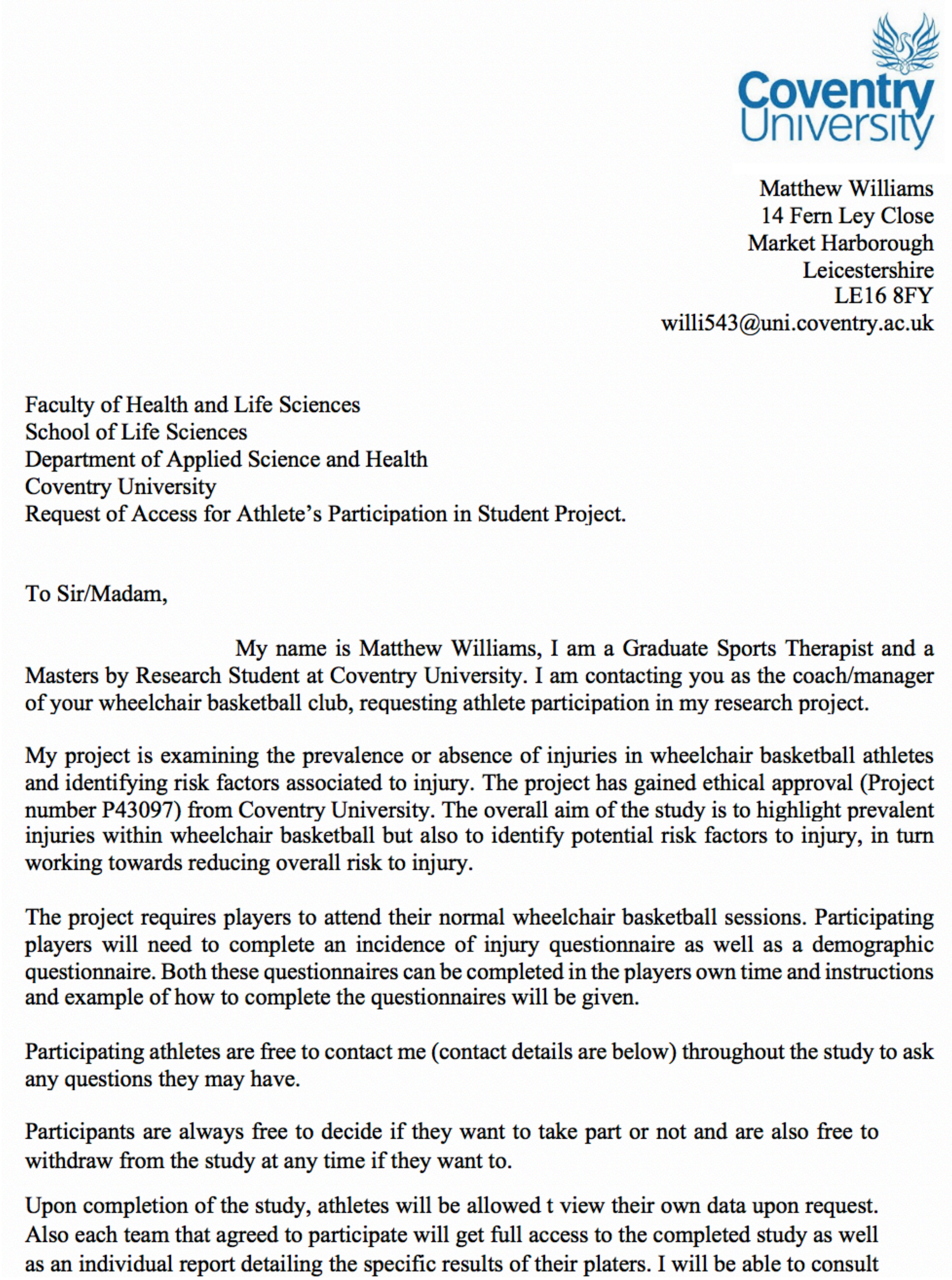
Date of approval:

28 October 2016

Project Reference Number:

P43097

Appendix 2 Gatekeepers Letter '



Coventry
University

Matthew Williams
14 Fern Ley Close
Market Harborough
Leicestershire
LE16 8FY
willi543@uni.coventry.ac.uk

Faculty of Health and Life Sciences
School of Life Sciences
Department of Applied Science and Health
Coventry University
Request of Access for Athlete’s Participation in Student Project.

To Sir/Madam,

My name is Matthew Williams, I am a Graduate Sports Therapist and a Masters by Research Student at Coventry University. I am contacting you as the coach/manager of your wheelchair basketball club, requesting athlete participation in my research project.

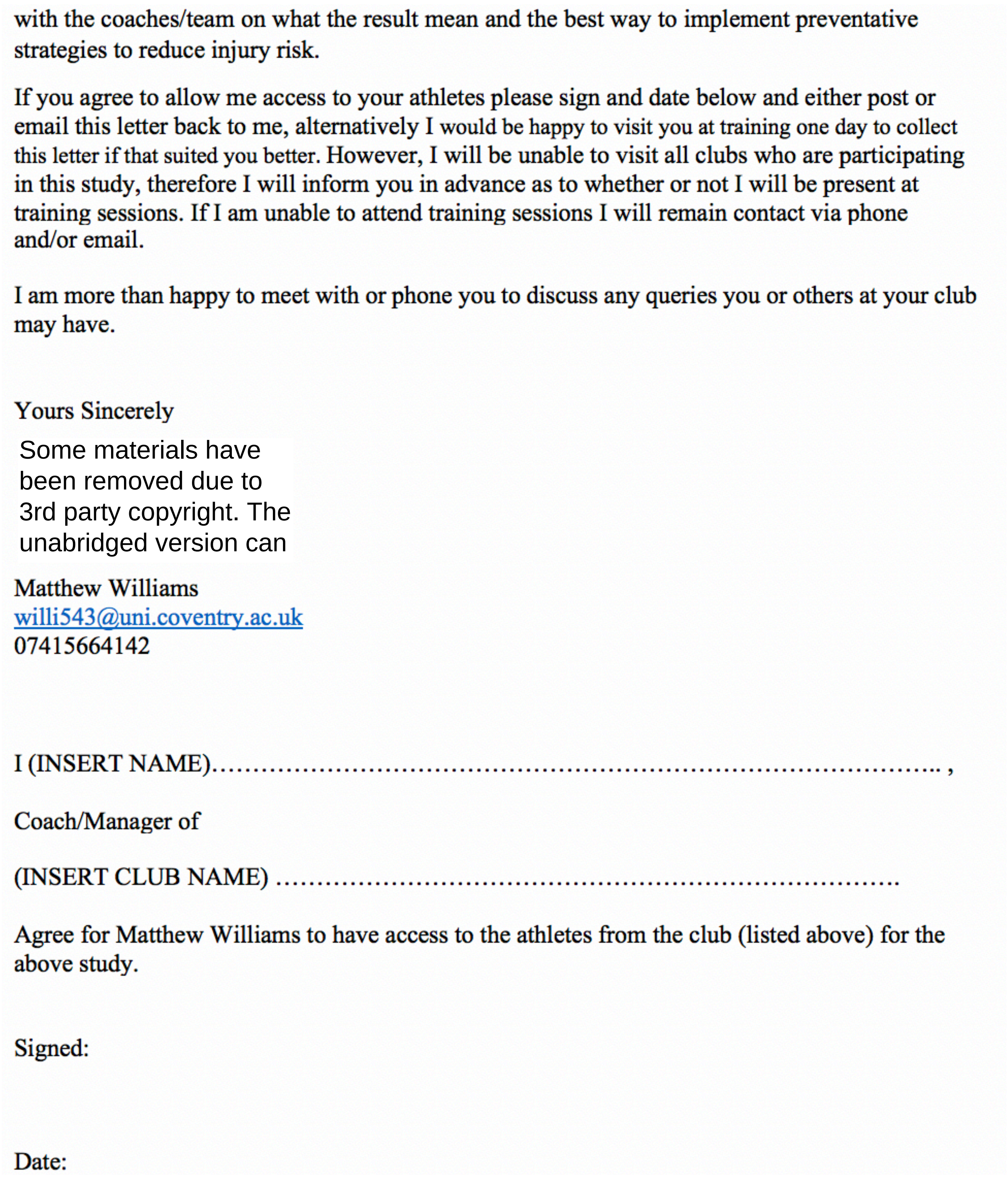
My project is examining the prevalence or absence of injuries in wheelchair basketball athletes and identifying risk factors associated to injury. The project has gained ethical approval (Project number P43097) from Coventry University. The overall aim of the study is to highlight prevalent injuries within wheelchair basketball but also to identify potential risk factors to injury, in turn working towards reducing overall risk to injury.

The project requires players to attend their normal wheelchair basketball sessions. Participating players will need to complete an incidence of injury questionnaire as well as a demographic questionnaire. Both these questionnaires can be completed in the players own time and instructions and example of how to complete the questionnaires will be given.

Participating athletes are free to contact me (contact details are below) throughout the study to ask any questions they may have.

Participants are always free to decide if they want to take part or not and are also free to withdraw from the study at any time if they want to.

Upon completion of the study, athletes will be allowed t view their own data upon request. Also each team that agreed to participate will get full access to the completed study as well as an individual report detailing the specific results of their platers. I will be able to consult



with the coaches/team on what the result mean and the best way to implement preventative strategies to reduce injury risk.

If you agree to allow me access to your athletes please sign and date below and either post or email this letter back to me, alternatively I would be happy to visit you at training one day to collect this letter if that suited you better. However, I will be unable to visit all clubs who are participating in this study, therefore I will inform you in advance as to whether or not I will be present at training sessions. If I am unable to attend training sessions I will remain contact via phone and/or email.

I am more than happy to meet with or phone you to discuss any queries you or others at your club may have.

Yours Sincerely

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Matthew Williams
willi543@uni.coventry.ac.uk
07415664142

I (INSERT NAME)……………………………………………………………………………….. ,

Coach/Manager of

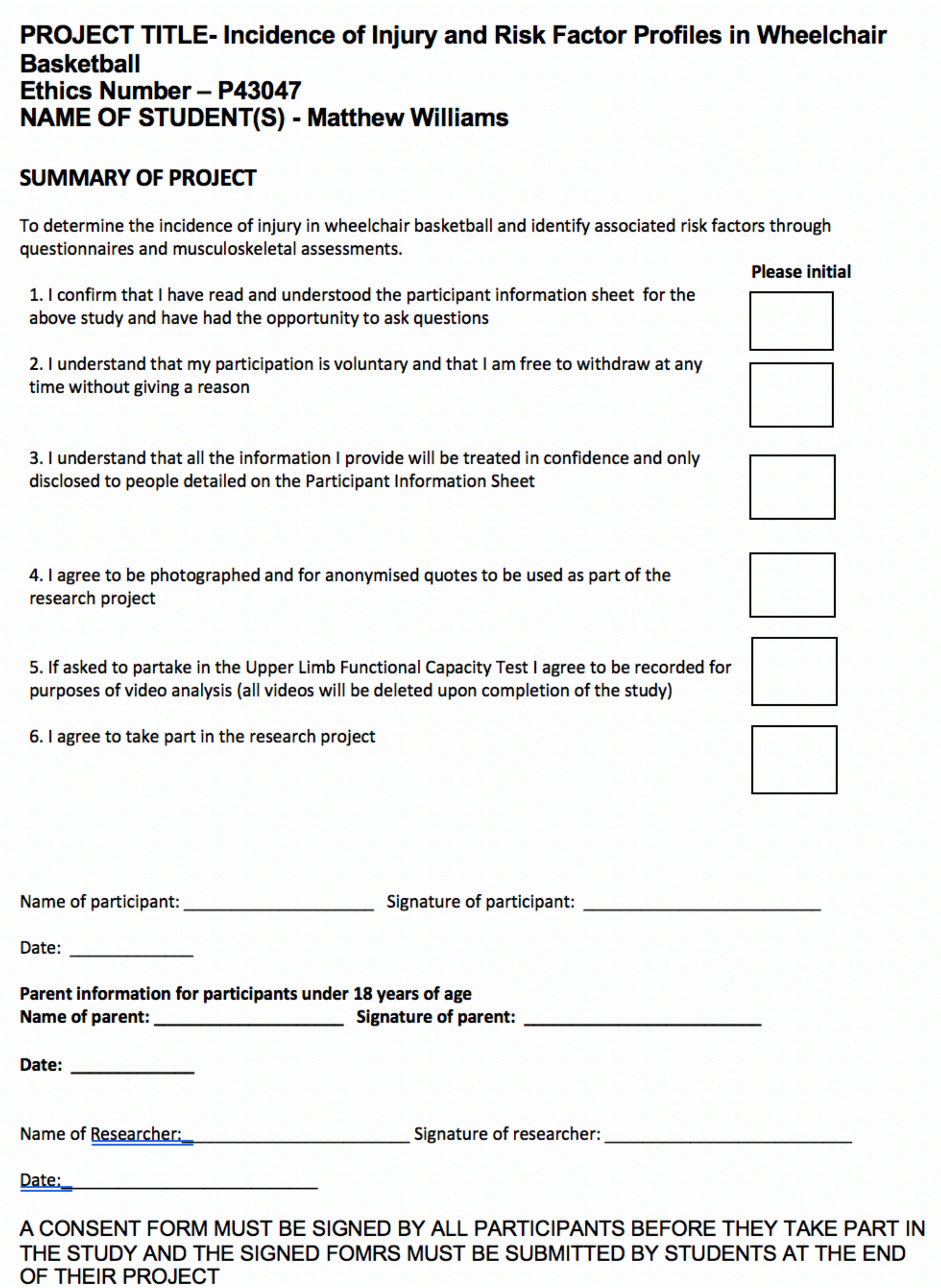
(INSERT CLUB NAME) ……………………………………………………………………….

Agree for Matthew Williams to have access to the athletes from the club (listed above) for the above study.

Signed:

Date:

Appendix 3: Informed Consent '



PROJECT TITLE- Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball
Ethics Number – P43047
NAME OF STUDENT(S) - Matthew Williams

SUMMARY OF PROJECT

To determine the incidence of injury in wheelchair basketball and identify associated risk factors through questionnaires and musculoskeletal assessments.

Please initial

1. I confirm that I have read and understood the participant information sheet for the above study and have had the opportunity to ask questions ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason ☐
3. I understand that all the information I provide will be treated in confidence and only disclosed to people detailed on the Participant Information Sheet ☐
4. I agree to be photographed and for anonymised quotes to be used as part of the research project ☐
5. If asked to partake in the Upper Limb Functional Capacity Test I agree to be recorded for purposes of video analysis (all videos will be deleted upon completion of the study) ☐
6. I agree to take part in the research project ☐

Name of participant: ______________________ Signature of participant: ___________________________

Date: ______________

Parent information for participants under 18 years of age
Name of parent: ______________________ Signature of parent: ___________________________

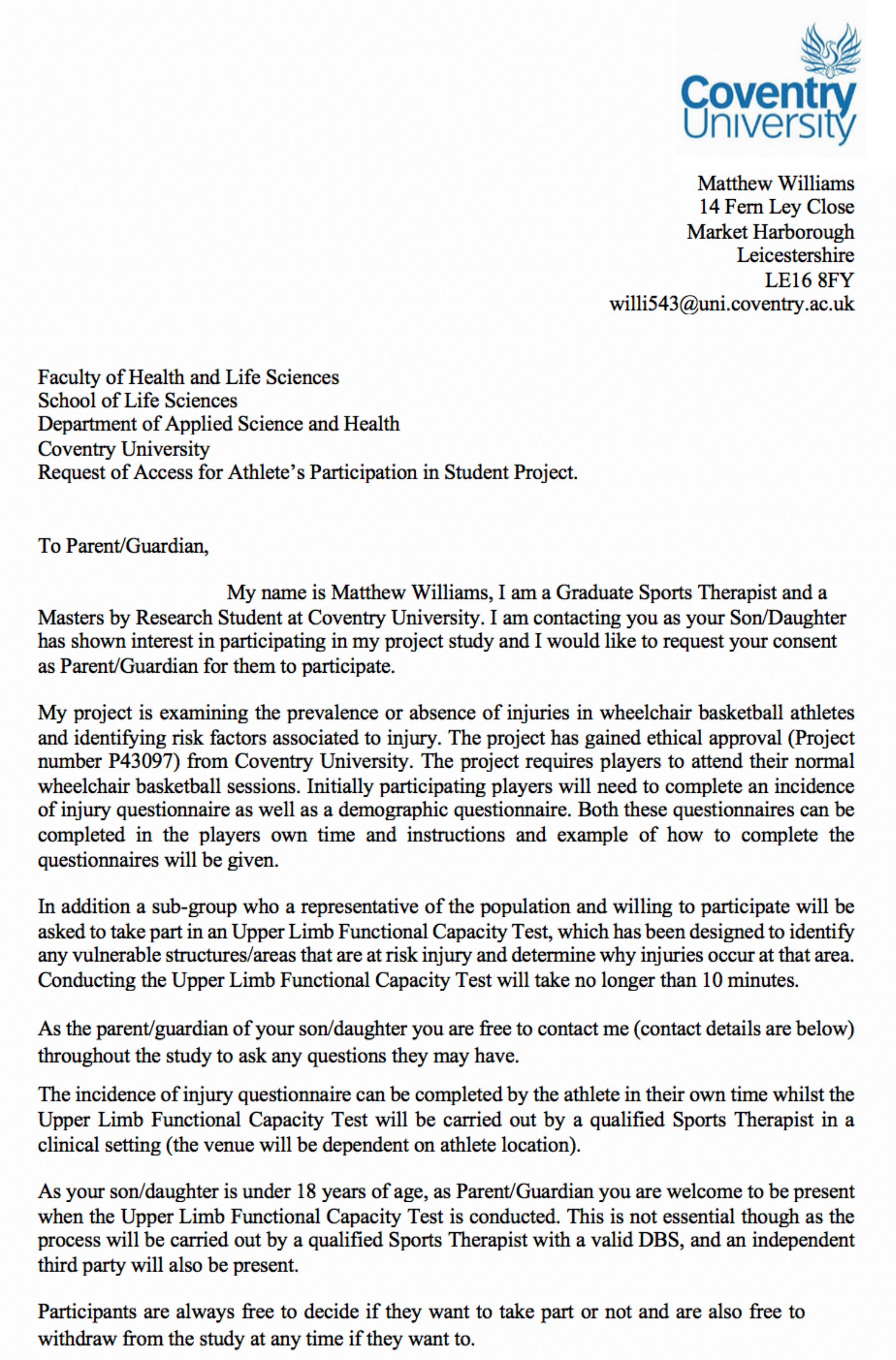
Date: ______________

Name of Researcher:_________________________ Signature of researcher: ___________________________

Date:____________________________

A CONSENT FORM MUST BE SIGNED BY ALL PARTICIPANTS BEFORE THEY TAKE PART IN THE STUDY AND THE SIGNED FOMRS MUST BE SUBMITTED BY STUDENTS AT THE END OF THEIR PROJECT

Appendix 4 Parent/Guardian Letter '



Matthew Williams
14 Fern Ley Close
Market Harborough
Leicestershire
LE16 8FY
willi543@uni.coventry.ac.uk

Faculty of Health and Life Sciences
School of Life Sciences
Department of Applied Science and Health
Coventry University
Request of Access for Athlete's Participation in Student Project.

To Parent/Guardian,

My name is Matthew Williams, I am a Graduate Sports Therapist and a Masters by Research Student at Coventry University. I am contacting you as your Son/Daughter has shown interest in participating in my project study and I would like to request your consent as Parent/Guardian for them to participate.

My project is examining the prevalence or absence of injuries in wheelchair basketball athletes and identifying risk factors associated to injury. The project has gained ethical approval (Project number P43097) from Coventry University. The project requires players to attend their normal wheelchair basketball sessions. Initially participating players will need to complete an incidence of injury questionnaire as well as a demographic questionnaire. Both these questionnaires can be completed in the players own time and instructions and example of how to complete the questionnaires will be given.

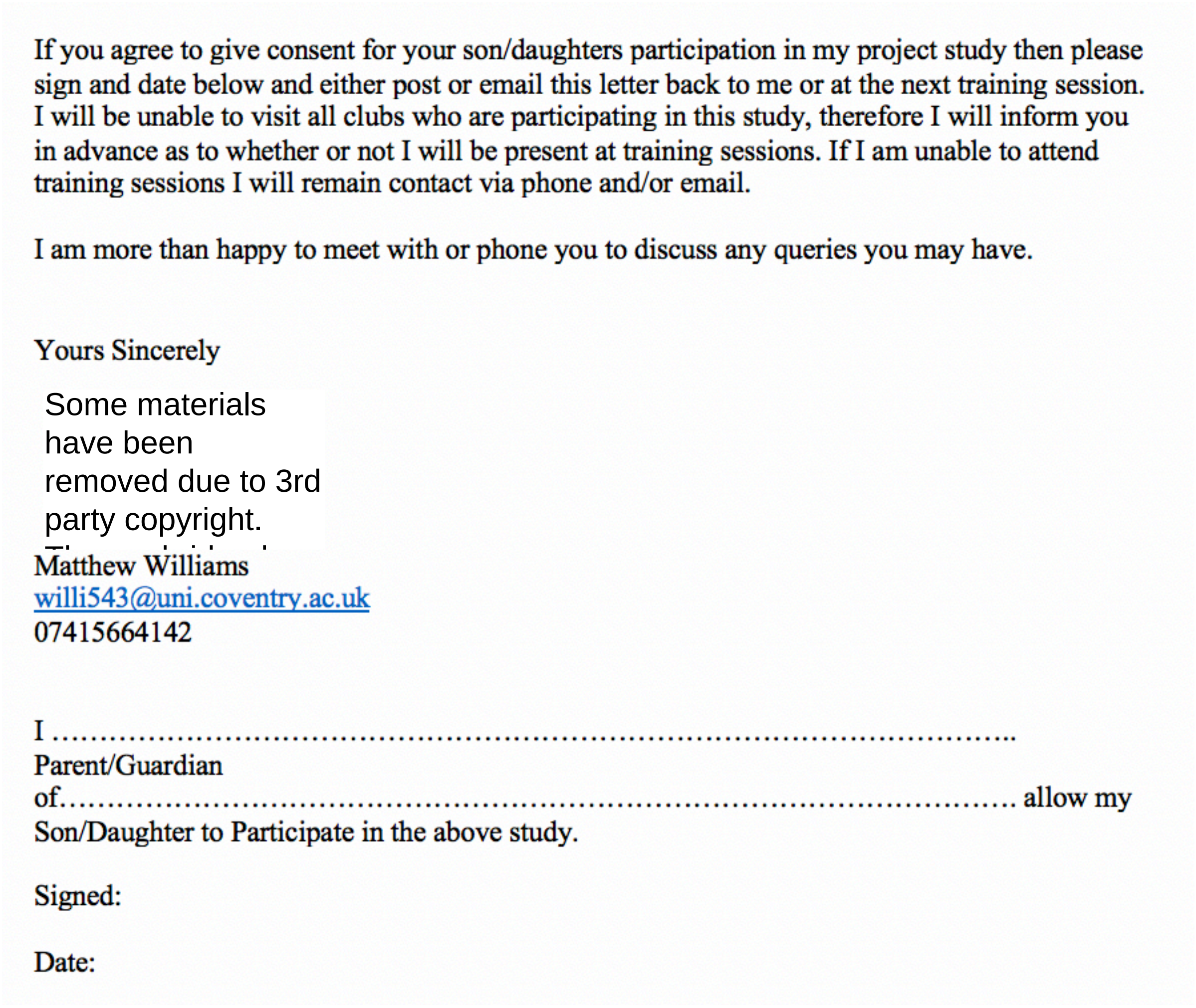
In addition a sub-group who a representative of the population and willing to participate will be asked to take part in an Upper Limb Functional Capacity Test, which has been designed to identify any vulnerable structures/areas that are at risk injury and determine why injuries occur at that area. Conducting the Upper Limb Functional Capacity Test will take no longer than 10 minutes.

As the parent/guardian of your son/daughter you are free to contact me (contact details are below) throughout the study to ask any questions they may have.

The incidence of injury questionnaire can be completed by the athlete in their own time whilst the Upper Limb Functional Capacity Test will be carried out by a qualified Sports Therapist in a clinical setting (the venue will be dependent on athlete location).

As your son/daughter is under 18 years of age, as Parent/Guardian you are welcome to be present when the Upper Limb Functional Capacity Test is conducted. This is not essential though as the process will be carried out by a qualified Sports Therapist with a valid DBS, and an independent third party will also be present.

Participants are always free to decide if they want to take part or not and are also free to withdraw from the study at any time if they want to.



If you agree to give consent for your son/daughters participation in my project study then please sign and date below and either post or email this letter back to me or at the next training session. I will be unable to visit all clubs who are participating in this study, therefore I will inform you in advance as to whether or not I will be present at training sessions. If I am unable to attend training sessions I will remain contact via phone and/or email.

I am more than happy to meet with or phone you to discuss any queries you may have.

Yours Sincerely

Some materials have been removed due to 3rd party copyright.

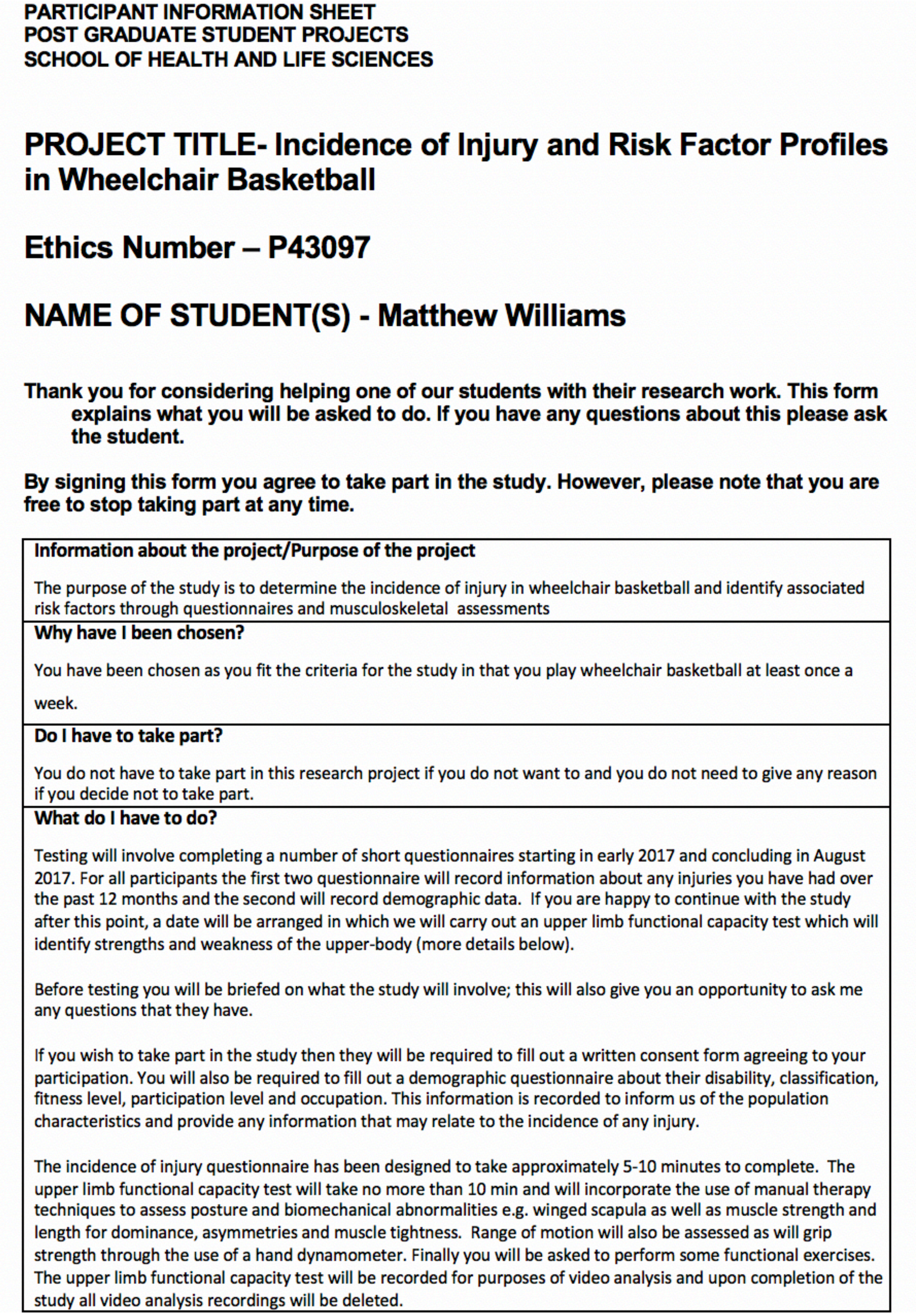
Matthew Williams
willi543@uni.coventry.ac.uk
07415664142

I ………………………………………………………………………………………………..
Parent/Guardian
of………………………………………………………………………………………… allow my Son/Daughter to Participate in the above study.

Signed:

Date:

Appendix 5: Participation Information '



PARTICIPANT INFORMATION SHEET
POST GRADUATE STUDENT PROJECTS
SCHOOL OF HEALTH AND LIFE SCIENCES

PROJECT TITLE- Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball

Ethics Number – P43097

NAME OF STUDENT(S) - Matthew Williams

Thank you for considering helping one of our students with their research work. This form explains what you will be asked to do. If you have any questions about this please ask the student.

By signing this form you agree to take part in the study. However, please note that you are free to stop taking part at any time.

Information about the project/Purpose of the project

The purpose of the study is to determine the incidence of injury in wheelchair basketball and identify associated risk factors through questionnaires and musculoskeletal assessments

Why have I been chosen?

You have been chosen as you fit the criteria for the study in that you play wheelchair basketball at least once a week.

Do I have to take part?

You do not have to take part in this research project if you do not want to and you do not need to give any reason if you decide not to take part.

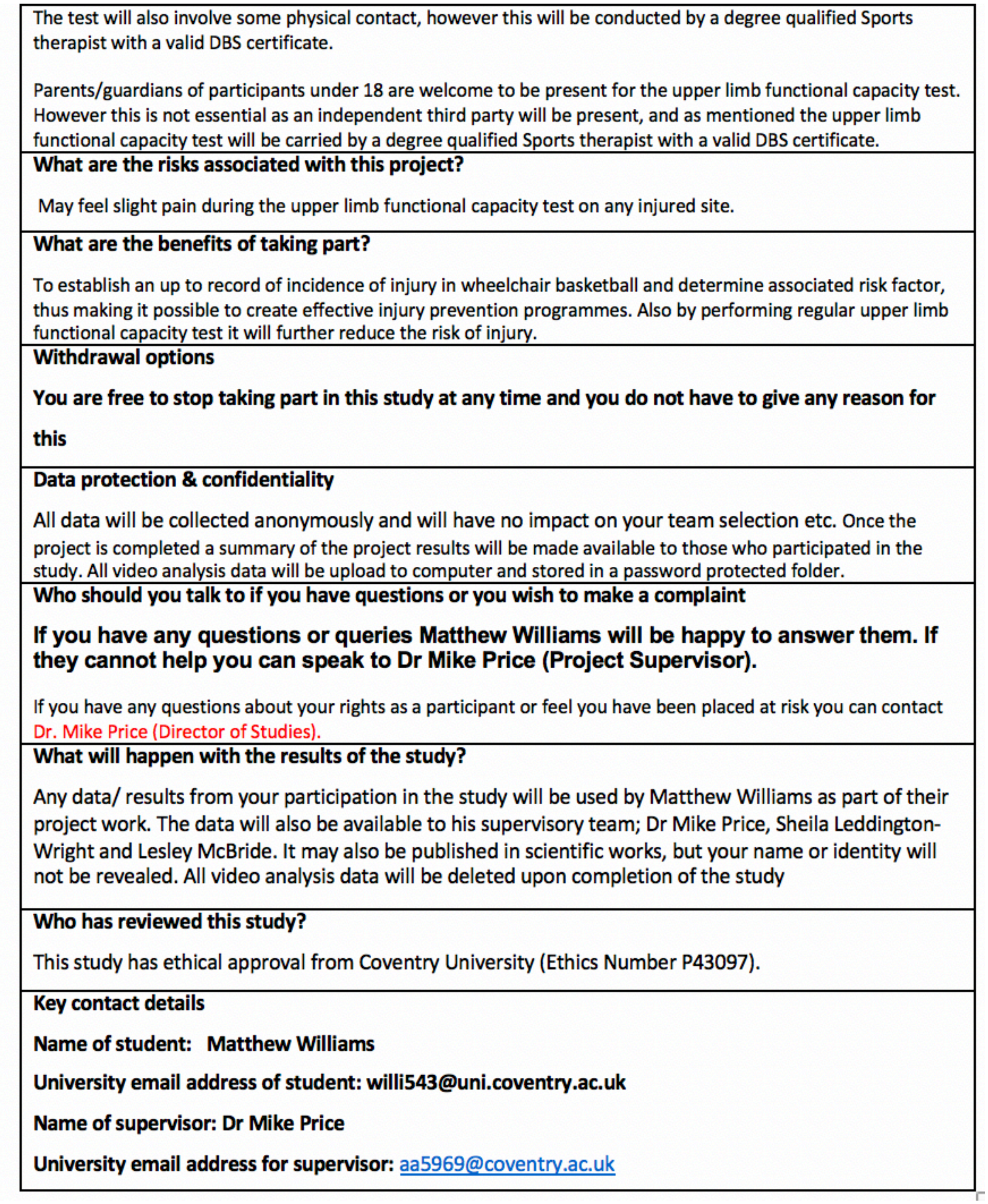
What do I have to do?

Testing will involve completing a number of short questionnaires starting in early 2017 and concluding in August 2017. For all participants the first two questionnaire will record information about any injuries you have had over the past 12 months and the second will record demographic data. If you are happy to continue with the study after this point, a date will be arranged in which we will carry out an upper limb functional capacity test which will identify strengths and weakness of the upper-body (more details below).

Before testing you will be briefed on what the study will involve; this will also give you an opportunity to ask me any questions that they have.

If you wish to take part in the study then they will be required to fill out a written consent form agreeing to your participation. You will also be required to fill out a demographic questionnaire about their disability, classification, fitness level, participation level and occupation. This information is recorded to inform us of the population characteristics and provide any information that may relate to the incidence of any injury.

The incidence of injury questionnaire has been designed to take approximately 5-10 minutes to complete. The upper limb functional capacity test will take no more than 10 min and will incorporate the use of manual therapy techniques to assess posture and biomechanical abnormalities e.g. winged scapula as well as muscle strength and length for dominance, asymmetries and muscle tightness. Range of motion will also be assessed as will grip strength through the use of a hand dynamometer. Finally you will be asked to perform some functional exercises. The upper limb functional capacity test will be recorded for purposes of video analysis and upon completion of the study all video analysis recordings will be deleted.



The test will also involve some physical contact, however this will be conducted by a degree qualified Sports therapist with a valid DBS certificate.

Parents/guardians of participants under 18 are welcome to be present for the upper limb functional capacity test. However this is not essential as an independent third party will be present, and as mentioned the upper limb functional capacity test will be carried by a degree qualified Sports therapist with a valid DBS certificate.

What are the risks associated with this project?

May feel slight pain during the upper limb functional capacity test on any injured site.

What are the benefits of taking part?

To establish an up to record of incidence of injury in wheelchair basketball and determine associated risk factor, thus making it possible to create effective injury prevention programmes. Also by performing regular upper limb functional capacity test it will further reduce the risk of injury.

Withdrawal options

You are free to stop taking part in this study at any time and you do not have to give any reason for this

Data protection & confidentiality

All data will be collected anonymously and will have no impact on your team selection etc. Once the project is completed a summary of the project results will be made available to those who participated in the study. All video analysis data will be upload to computer and stored in a password protected folder.

Who should you talk to if you have questions or you wish to make a complaint

If you have any questions or queries Matthew Williams will be happy to answer them. If they cannot help you can speak to Dr Mike Price (Project Supervisor).

If you have any questions about your rights as a participant or feel you have been placed at risk you can contact Dr. Mike Price (Director of Studies).

What will happen with the results of the study?

Any data/ results from your participation in the study will be used by Matthew Williams as part of their project work. The data will also be available to his supervisory team; Dr Mike Price, Sheila Leddington-Wright and Lesley McBride. It may also be published in scientific works, but your name or identity will not be revealed. All video analysis data will be deleted upon completion of the study

Who has reviewed this study?

This study has ethical approval from Coventry University (Ethics Number P43097).

Key contact details

Name of student: Matthew Williams

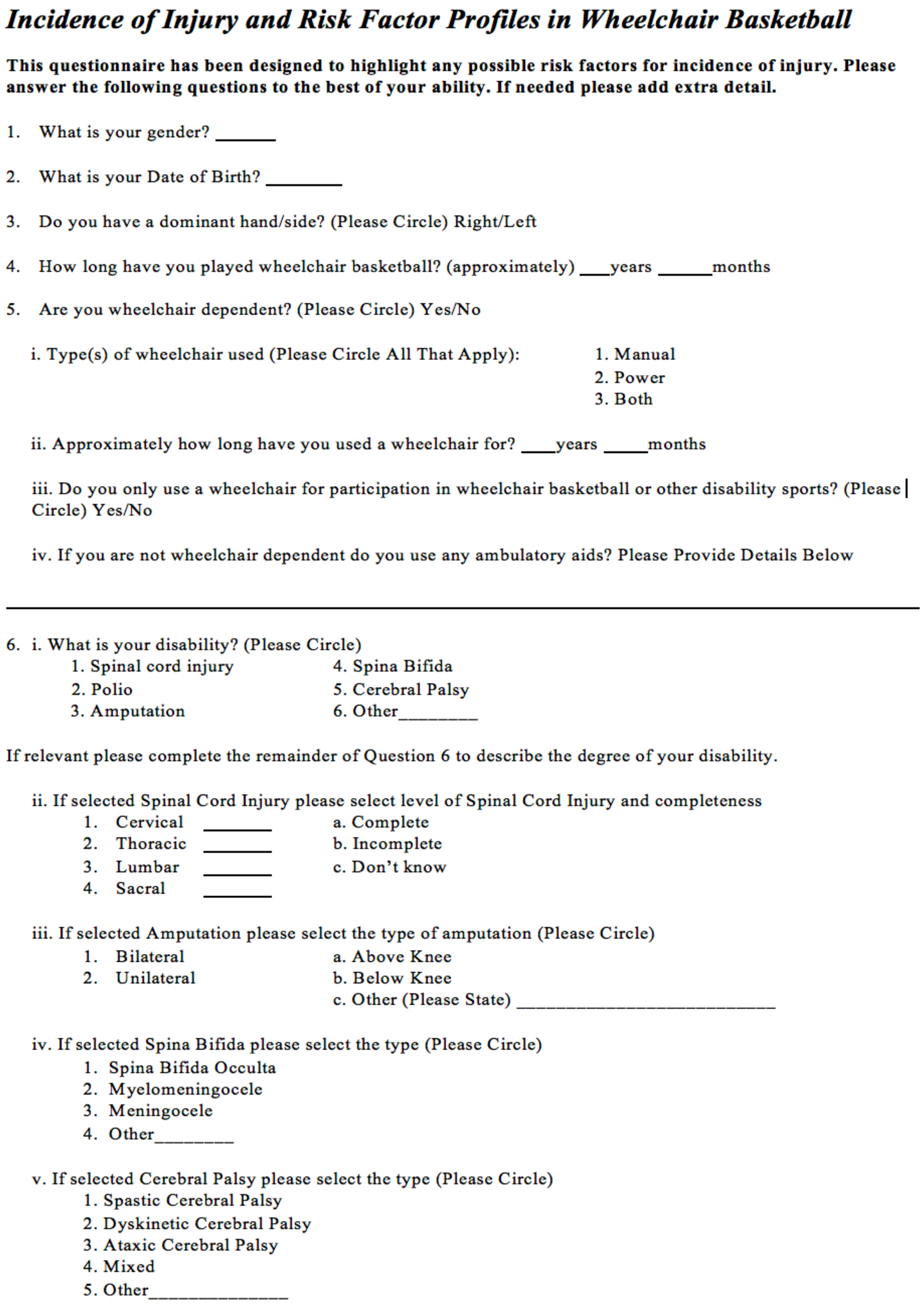
University email address of student: willi543@uni.coventry.ac.uk

Name of supervisor: Dr Mike Price

University email address for supervisor: aa5969@coventry.ac.uk

Appendix 6: Demographic Questionnaire '

Based on the demographic questionnaire used by Curtis and Black (1999). '



Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball

This questionnaire has been designed to highlight any possible risk factors for incidence of injury. Please answer the following questions to the best of your ability. If needed please add extra detail.

1. What is your gender? ______
2. What is your Date of Birth? ________
3. Do you have a dominant hand/side? (Please Circle) Right/Left
4. How long have you played wheelchair basketball? (approximately) ___years _____months
5. Are you wheelchair dependent? (Please Circle) Yes/No

   i. Type(s) of wheelchair used (Please Circle All That Apply):
   1. Manual
   2. Power
   3. Both

   ii. Approximately how long have you used a wheelchair for? ____years _____months

   iii. Do you only use a wheelchair for participation in wheelchair basketball or other disability sports? (Please Circle) Yes/No

   iv. If you are not wheelchair dependent do you use any ambulatory aids? Please Provide Details Below

____

6. i. What is your disability? (Please Circle)
   1. Spinal cord injury
   2. Polio
   3. Amputation
   4. Spina Bifida
   5. Cerebral Palsy
   6. Other________

If relevant please complete the remainder of Question 6 to describe the degree of your disability.

   ii. If selected Spinal Cord Injury please select level of Spinal Cord Injury and completeness

1. Cervical _______	a. Complete
2. Thoracic _______	b. Incomplete
3. Lumbar _______	c. Don't know
4. Sacral _______	

   iii. If selected Amputation please select the type of amputation (Please Circle)

1. Bilateral	a. Above Knee
2. Unilateral	b. Below Knee
	c. Other (Please State) ___________________________

   iv. If selected Spina Bifida please select the type (Please Circle)
   1. Spina Bifida Occulta
   2. Myelomeningocele
   3. Meningocele
   4. Other________

   v. If selected Cerebral Palsy please select the type (Please Circle)
   1. Spastic Cerebral Palsy
   2. Dyskinetic Cerebral Palsy
   3. Ataxic Cerebral Palsy
   4. Mixed
   5. Other______________

vi. If your disability was under the ‘Other’ category and has a grade/type e.g. Muscular Dystrophy or Ehlers-Danlos Syndrome please state the grade/type here ____________________

7. What is your point’s classification for wheelchair basketball? e.g. 3.5____________________

8. On average how many times a week do you train for wheelchair basketball? ____________________

    i. Approximately how many hours? ________hours

    ii. Approximately how many weeks a year do you participate in wheelchair basketball? ______weeks

9. Have ever represented a national team or been part of the national training squad? ______________

10. What division do you primary play in? ____________________

11. If you play in the junior league please state the team and age group you play in____________________

12. Do you do any other physical activity besides wheelchair basketball e.g. strength and conditioning/sport/fitness training? (Please Circle) Yes/No

    i. What type of activity is it?____________________

    ii. Approximately how many times a week do you do this type of exercise? ____________________

    iii. Approximately how many hours a week are spent in these other activities? _____________hours

13. Are you currently in education: full-time/part-time or/and work: full-time/part-time/employed/voluntary/self-employed/freelance. **Please highlight all relevant sections**

14. What is your current primary occupation? ____________________

    i. Approximately how many hours do you spend at work/school a week? ___________hours

15. A). Do you drive? (Please Circle)
    1. Yes
    2. No

    B). If yes, number of hours spent driving per week: _______hours

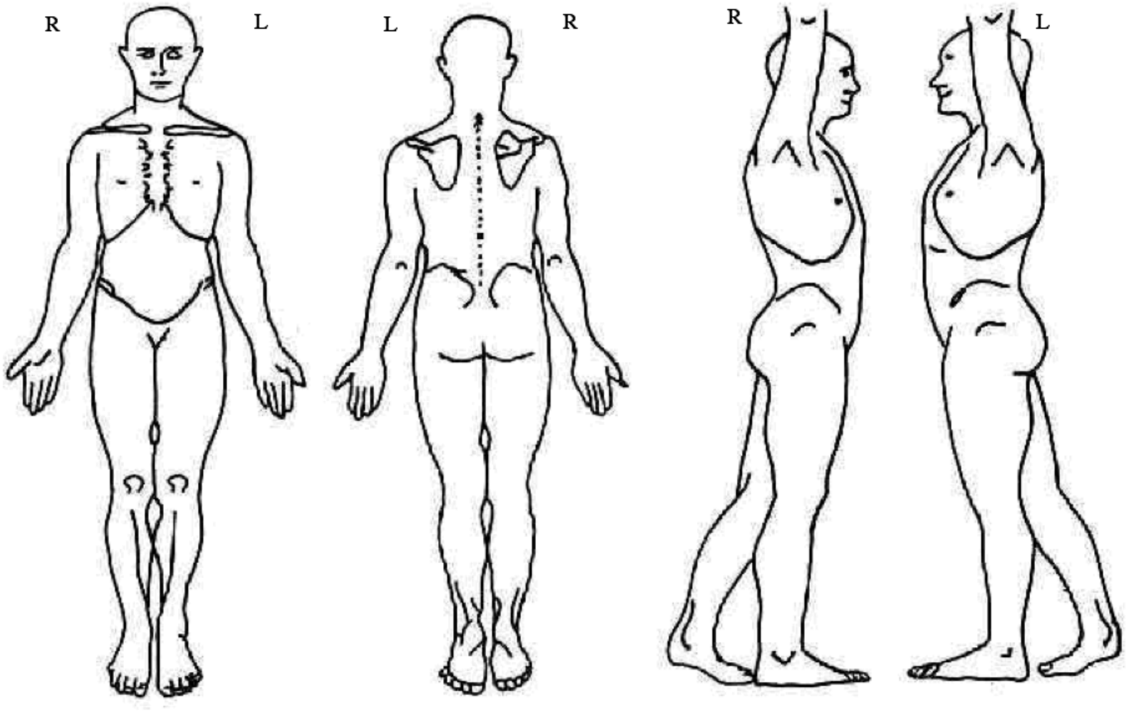
    C). If yes, what type of vehicle? (Please Circle)
    1. Car
    2. Van with lift
    3. Van without lift
    4. Truck/utility vehicle
    5. Other ___________

D). Do you manually lift/maneuver your wheelchair in and around your Vehicle? (Please Circle) Yes/No

16. Do you consider yourself physically fit to play wheelchair basketball? If you are currently injured/returning from injury base your fitness on pre-injury status. (Please Circle) Yes/No

Appendix 7: Injury Questionnaire '

Records of Incidence of Injury



On the body chart above please shade any areas where you have sustained an injury in the last 12 months. Please include all injuries, including those not sustained in wheelchair basketball e.g. Pressure Sores. If you have had multiple injuries at the same or different sites please mark them clearly by using P1, P2, P3 etc. to mark each individual injury.
An injury is defined as any musculoskeletal or neurological complaint prompting an athlete to seek medical attention, regardless of whether or not the complaint resulted in lost time from training or competition

Please can you answer the questions on page1 and 2 to the best of your ability. If you have multiple injuries answer all questions for all of your injuries. If you are unsure what your injury was please refer to it as an undiagnosed injury.

Please refer back to the example questionnaire for guidance.

If needed please add extra detail.

Please answer the following questions to the best of your ability.

1. What was the injury(s)? If a ligament/muscle/tendon tear please provide the grade of tear and the specific ligament/muscle/tendon injuries if known

2. What activity were you doing at the time of injury(s)?

3. What was the mechanism of your injury(s)?

4. Approximately what month and year did the injury(s) occur?

5. Did you seek professional advice/treatment from a Sports Therapist, Physiotherapist, Doctor/GP, Osteopath, or internet?

6. Did the injury(s) require surgery? If yes please provide any details. Yes/No

7. How long was it until you returned to participation in wheelchair basketball?

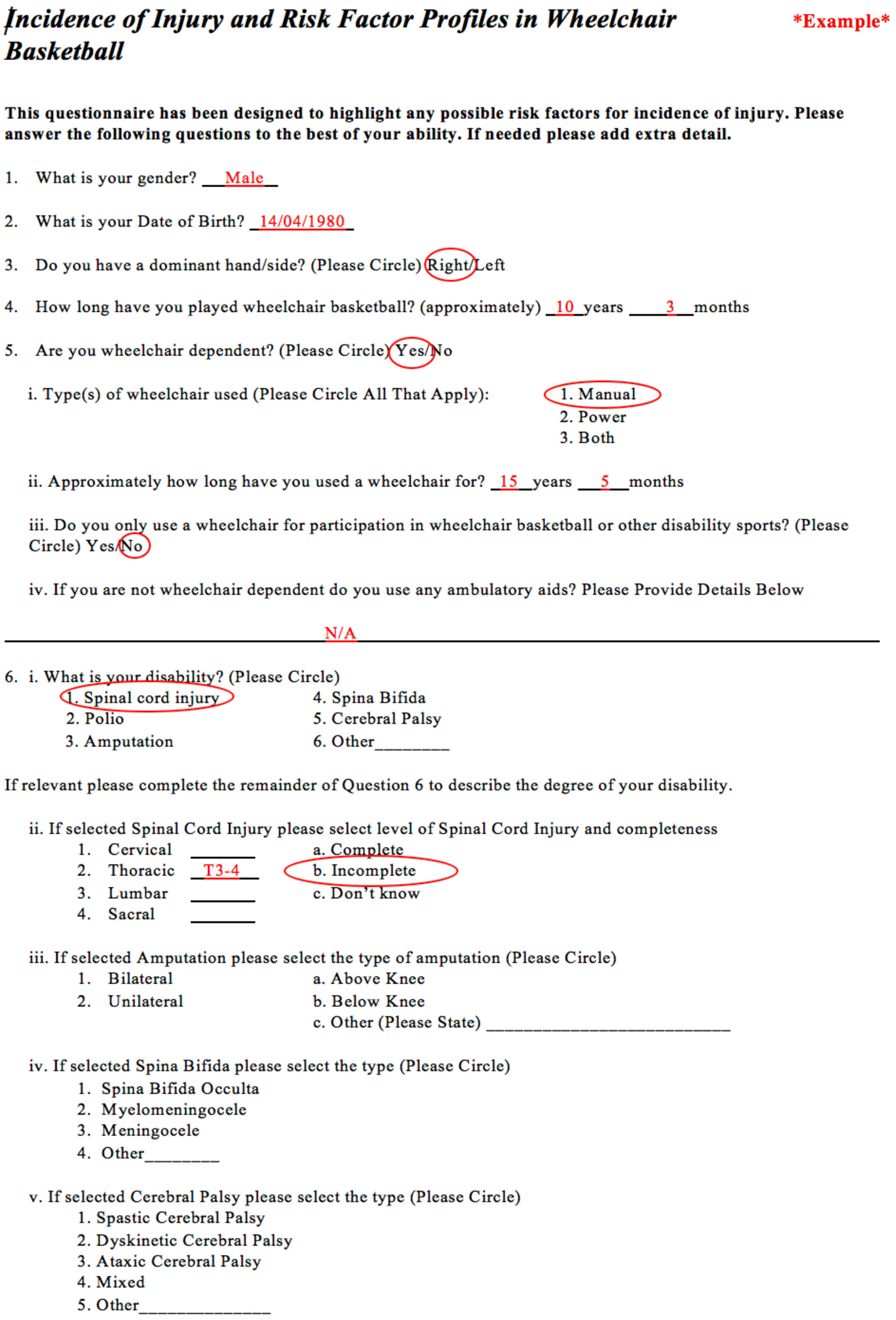
   ____Days _______Weeks _________ Months

8. On a scale of 0 – 10 on average how would you rate, the following:
   i. General daily fatigue
      0 1 2 3 4 5 6 7 8 9 10
      Note: 0 is no problem, 10 is noticeably tired/fatigued

   ii. Recovery from training sessions
      0 1 2 3 4 5 6 7 8 9 10
      Note: 0 is no problem, 10 is noticeably struggling to recover

   iii. General do you feel you can cope with the demands of each training session regardless of the intensity.
      0 1 2 3 4 5 6 7 8 9 10
      Note: 0 is no problem, 10 is noticeably struggling to maintain performance.

Appendix 8: Example Demographic Questionnaire '



Incidence of Injury and Risk Factor Profiles in Wheelchair Basketball

Example

This questionnaire has been designed to highlight any possible risk factors for incidence of injury. Please answer the following questions to the best of your ability. If needed please add extra detail.

1. What is your gender? __Male__
2. What is your Date of Birth? _14/04/1980_
3. Do you have a dominant hand/side? (Please Circle) [✓ Right]/Left
4. How long have you played wheelchair basketball? (approximately) _10_years ____3__months
5. Are you wheelchair dependent? (Please Circle) [✓ Yes]/No

   i. Type(s) of wheelchair used (Please Circle All That Apply):
   [✓ 1. Manual]
   2. Power
   3. Both

   ii. Approximately how long have you used a wheelchair for? _15_years ___5__months

   iii. Do you only use a wheelchair for participation in wheelchair basketball or other disability sports? (Please Circle) Yes/[✓ No]

   iv. If you are not wheelchair dependent do you use any ambulatory aids? Please Provide Details Below

   N/A

6. i. What is your disability? (Please Circle)

   [✓ 1. Spinal cord injury]
   2. Polio
   3. Amputation
   4. Spina Bifida
   5. Cerebral Palsy
   6. Other________

If relevant please complete the remainder of Question 6 to describe the degree of your disability.

ii. If selected Spinal Cord Injury please select level of Spinal Cord Injury and completeness

1. Cervical _______
2. Thoracic _T3-4_
3. Lumbar _______
4. Sacral _______

a. Complete
[✓ b. Incomplete]
c. Don't know

iii. If selected Amputation please select the type of amputation (Please Circle)

1. Bilateral
2. Unilateral

a. Above Knee
b. Below Knee
c. Other (Please State) ___________________________

iv. If selected Spina Bifida please select the type (Please Circle)

1. Spina Bifida Occulta
2. Myelomeningocele
3. Meningocele
4. Other________

v. If selected Cerebral Palsy please select the type (Please Circle)

1. Spastic Cerebral Palsy
2. Dyskinetic Cerebral Palsy
3. Ataxic Cerebral Palsy
4. Mixed
5. Other______________

vi. If your disability was under the 'Other' category and has a grade/type e.g. Muscular Dystrophy or Ehlers-Danlos Syndrome please state the grade/type here N/A

7. What is your point's classification for wheelchair basketball? e.g. 3.5 1.5

8. On average how many times a week do you train for wheelchair basketball? 3

   i. Approximately how many hours? 7 hours

   ii. Approximately how many weeks a year do you participate in wheelchair basketball? 40 weeks

9. Have ever represented a national team or been part of the national training squad? Yes

10. What division do you primary play in? National 2nd Division South

11. If you play in the junior league please state the team and age group you play in N/A

12. Do you do any other physical activity besides wheelchair basketball e.g. strength and conditioning/sport/fitness training? (Please Circle) [✓ Yes]/No

    i. What type of activity is it? Attend the Gym

    ii. Approximately how many times a week do you do this type of exercise? 2-3

    iii. Approximately how many hours a week are spent in these other activities? 3 hours

13. Are you currently in education: full-time/part-time or/and work: full-time/part-time/employed/voluntary/self-employed/freelance. **Please highlight all relevant sections**

14. What is your current primary occupation? Receptionist

    i. Approximately how many hours do you spend at work/school a week? 37.5 hours

15. A). Do you drive? (Please Circle)
    [✓ 1. Yes]
    2. No

    B). If yes, number of hours spent driving per week: 6 hours

    C). If yes, what type of vehicle? (Please Circle)
    [✓ 1. Car]
    2. Van with lift
    3. Van without lift
    4. Truck/utility vehicle
    5. Other ___________

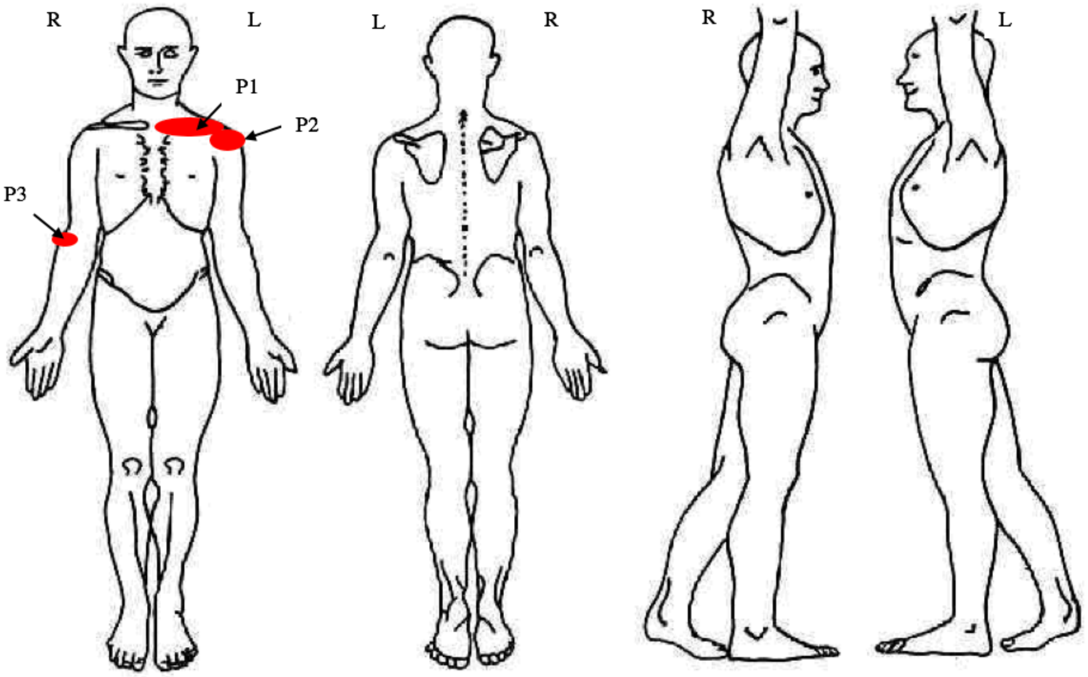
D). Do you manually lift/maneuver your wheelchair in and around your Vehicle? (Please Circle) [✓ Yes]/No

16. Do you consider yourself physically fit to play wheelchair basketball? If you are currently injured/returning from injury base your fitness on pre-injury status. (Please Circle) [✓ Yes]/No

Appendix 9: Example Injury Questionnaire '

Records of Incidence of Injury

Example



On the body chart above please shade any areas where you have sustained an injury in the last 12 months. Please include all injuries (see below definition), including those not sustained in wheelchair basketball e.g. Pressure Sore. If you have had multiple injuries at the same or different sites please mark them clearly by using P1, P2, P3 etc. to mark each individual injury.
An injury is defined as any musculoskeletal or neurological complaint prompting an athlete to seek medical attention, regardless of whether or not the complaint resulted in lost time from training or competition

Please can you answers the questions on page1 and 2 to the best of your ability. If you have multiple injuries answer all questions for all of your injuries. If you are unsure what your injury was please refer to it as an undiagnosed injury.

Please refer back to the example questionnaire for guidance.

If needed please add extra detail.

Please answer the following questions to the best of your ability.

1. What was the injury(s)? If a ligament/muscle/tendon tear please provide the grade of tear and the specific ligament/muscle/tendon injuries if known

   P1 = Fractured Collarbone

   P2 = Supraspinatus muscle tear Grade 1

   P3 = Tennis Elbow

2. What activity were you doing at the time of injury(s)?
   P1 = Wheelchair Basketball
   P2 = Wheelchair Basketball
   P3 = Work related injury

3. What was the mechanism of your injury(s)?
   P1 = Fell out of chair during preseason training
   P2 = Overreaching for a ball in basketball and arm
   P3 = Overuse from sitting at computer all day

4. Approximately what month and year did the injury(s) occur?
   P1 = August 2015
   P2 = December 2015
   P3 = March 2016

5. Did you seek professional advice/treatment from a Sports Therapist, Physiotherapist, Doctor/GP, Osteopath, or internet?
   P1 = Doctor and Sports Therapist
   P2 = Sports Therapist
   P3 = Self Diagnosed

6. Did the injury(s) require surgery? (Please Circle) If yes please provide any details. Yes/[✓ No]

   None of the injuries required surgery.

7. How long was it until you returned to participation in wheelchair basketball?

   P1= ___Days _______Weeks ____2____ Months

   P2= ___Days ___3___Weeks _________ Months

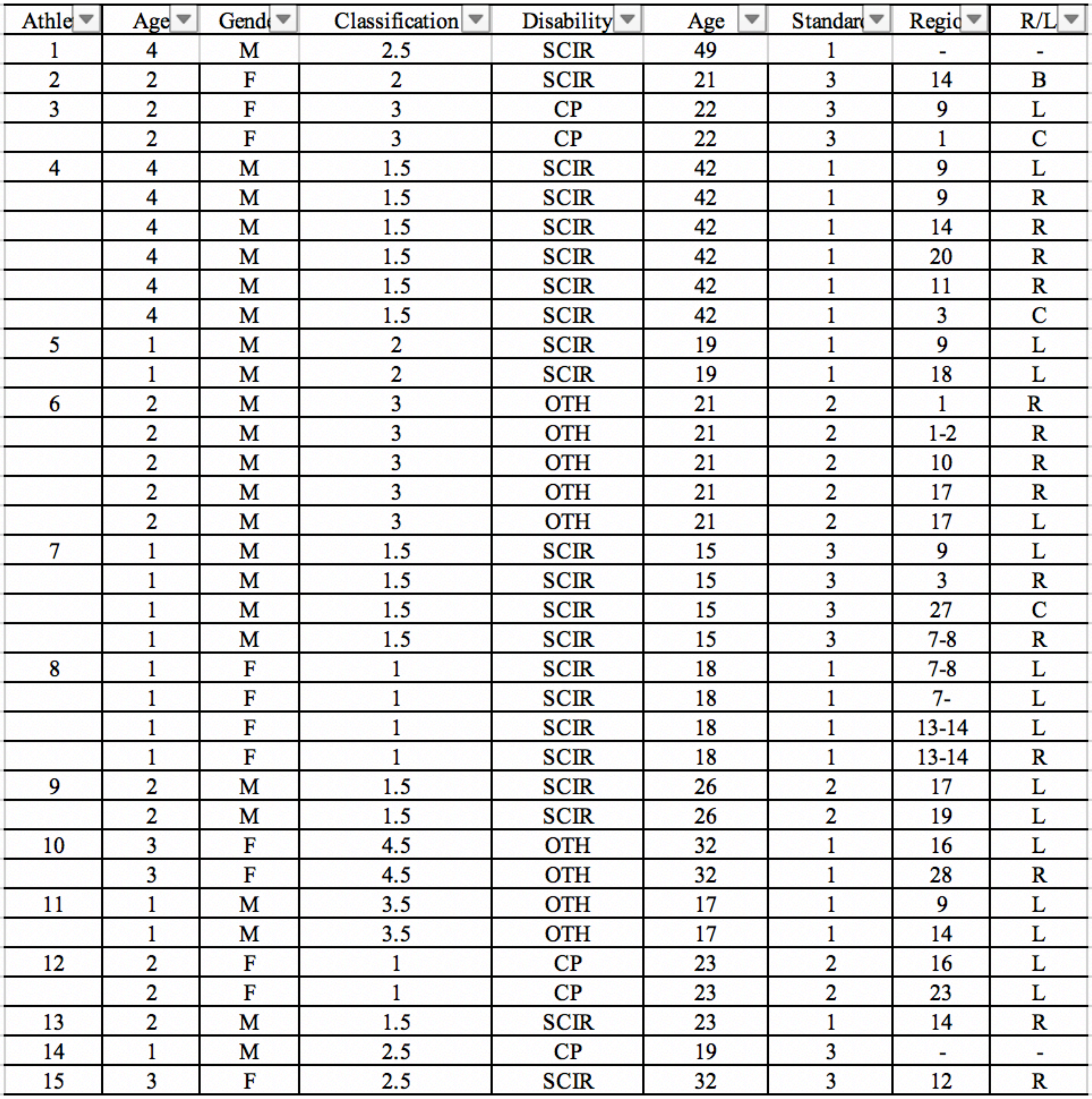
   P3= No time off taken.

8. On a scale of 0 – 10 on average how would you rate, the following:
   i. General daily fatigue
      0 1 [✓ 2] 3 4 5 6 7 8 9 10
      Note: 0 is no problem, 10 is noticeably tired/fatigued

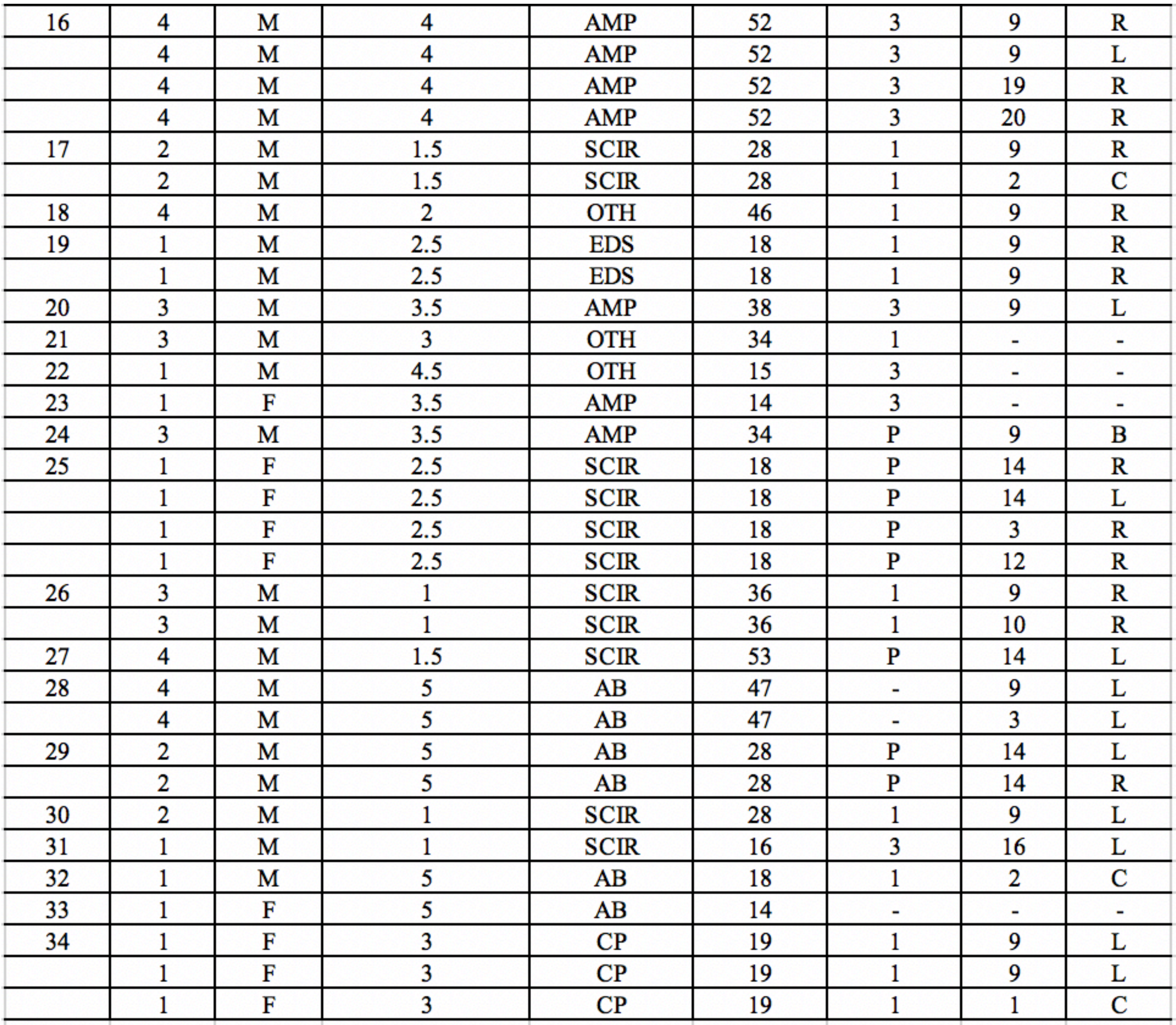
   ii. Recovery from training sessions
      0 1 2 3 4 5 [✓ 6] 7 8 9 10
      Note: 0 is no problem, 10 is noticeably struggling to recover

   iii. General do you feel you can cope with the demands of each training session regardless of the intensity.
      0 1 2 3 [✓ 4] 5 6 7 8 9 10
      Note: 0 is no problem, 10 is noticeably struggling to maintain performance.

Appendix 10: Raw Injury Data '



Athle	Age	Gend	Classification	Disability	Age	Standar	Regio	R/L
1	4	M	2.5	SCIR	49	1	-	-
2	2	F	2	SCIR	21	3	14	B
3	2	F	3	CP	22	3	9	L
	2	F	3	CP	22	3	1	C
4	4	M	1.5	SCIR	42	1	9	L
	4	M	1.5	SCIR	42	1	9	R
	4	M	1.5	SCIR	42	1	14	R
	4	M	1.5	SCIR	42	1	20	R
	4	M	1.5	SCIR	42	1	11	R
	4	M	1.5	SCIR	42	1	3	C
5	1	M	2	SCIR	19	1	9	L
	1	M	2	SCIR	19	1	18	L
6	2	M	3	OTH	21	2	1	R
	2	M	3	OTH	21	2	1-2	R
	2	M	3	OTH	21	2	10	R
	2	M	3	OTH	21	2	17	R
	2	M	3	OTH	21	2	17	L
7	1	M	1.5	SCIR	15	3	9	L
	1	M	1.5	SCIR	15	3	3	R
	1	M	1.5	SCIR	15	3	27	C
	1	M	1.5	SCIR	15	3	7-8	R
8	1	F	1	SCIR	18	1	7-8	L
	1	F	1	SCIR	18	1	7-	L
	1	F	1	SCIR	18	1	13-14	L
	1	F	1	SCIR	18	1	13-14	R
9	2	M	1.5	SCIR	26	2	17	L
	2	M	1.5	SCIR	26	2	19	L
10	3	F	4.5	OTH	32	1	16	L
	3	F	4.5	OTH	32	1	28	R
11	1	M	3.5	OTH	17	1	9	L
	1	M	3.5	OTH	17	1	14	L
12	2	F	1	CP	23	2	16	L
	2	F	1	CP	23	2	23	L
13	2	M	1.5	SCIR	23	1	14	R
14	1	M	2.5	CP	19	3	-	-
15	3	F	2.5	SCIR	32	3	12	R



16	4	M	4	AMP	52	3	9	R
	4	M	4	AMP	52	3	9	L
	4	M	4	AMP	52	3	19	R
	4	M	4	AMP	52	3	20	R
17	2	M	1.5	SCIR	28	1	9	R
	2	M	1.5	SCIR	28	1	2	C
18	4	M	2	OTH	46	1	9	R
19	1	M	2.5	EDS	18	1	9	R
	1	M	2.5	EDS	18	1	9	R
20	3	M	3.5	AMP	38	3	9	L
21	3	M	3	OTH	34	1	-	-
22	1	M	4.5	OTH	15	3	-	-
23	1	F	3.5	AMP	14	3	-	-
24	3	M	3.5	AMP	34	P	9	B
25	1	F	2.5	SCIR	18	P	14	R
	1	F	2.5	SCIR	18	P	14	L
	1	F	2.5	SCIR	18	P	3	R
	1	F	2.5	SCIR	18	P	12	R
26	3	M	1	SCIR	36	1	9	R
	3	M	1	SCIR	36	1	10	R
27	4	M	1.5	SCIR	53	P	14	L
28	4	M	5	AB	47	-	9	L
	4	M	5	AB	47	-	3	L
29	2	M	5	AB	28	P	14	L
	2	M	5	AB	28	P	14	R
30	2	M	1	SCIR	28	1	9	L
31	1	M	1	SCIR	16	3	16	L
32	1	M	5	AB	18	1	2	C
33	1	F	5	AB	14	-	-	-
34	1	F	3	CP	19	1	9	L
	1	F	3	CP	19	1	9	L
	1	F	3	CP	19	1	1	C

Appendix 11: Age Group Relative Risk Raw Data '

	INJURY	NO-INJURY	ROW TOTAL
UNDER 19	9	4	13
REMAINDER	19	2	21
COLUMN TOTAL	28	6	34

ROW 1	0.69
ROW 2	0.90
RELATIVE RISK	0.77

	INJURY	NO-INJURY	ROW TOTAL
20-30	9	0	9
REMAINDER	19	6	25
COLUMN TOTAL	28	6	34

ROW 1	1
ROW 2	0.76
RELATIVE RISK	1.32

	INJURY	NO-INJURY	ROW TOTAL
31-40	5	1	6
REMAINDER	23	5	28
COLUMN TOTAL	28	6	34

ROW 1	0.83
ROW 2	0.82
RELATIVE RISK	1.01

	INJURY	NO-INJURY	ROW TOTAL
41+	5	1	6
REMAINDER	23	5	28
COLUMN TOTAL	28	6	34

ROW 1	0.83
ROW 2	0.82
RELATIVE RISK	1.01

Appendix 12: Gender Relative Risk Raw Data '

	INJURY	NO-INJURY	ROW TOTAL
MALE	20	4	24
FEMALE	9	1	10
COLUMN TOTAL	29	5	34

ROW 1	0.83
ROW 2	0.90
RELATIVE RISK	0.93

	INJURY	NO-INJURY	ROW TOTAL
FEMALE	9	1	10
MALE	20	4	24
COLUMN TOTAL	29	5	34

ROW 1	0.90
ROW 2	0.83
RELATIVE RISK	1.08

Appendix 13: Classification Relative Risk Raw Data '

	INJURY	NO-INJURY	ROW TOTAL
1.0-1.5	11	0	11
REMAINDER	17	6	23
COLUMN TOTAL	28	6	34

ROW 1	1.00
ROW 2	0.74
RELATIVE RISK	1.35

	INJURY	NO-INJURY	ROW TOTAL
2.0-2.5	6	2	8
REMAINDER	22	4	26
COLUMN TOTAL	28	6	34

ROW 1	0.75
ROW 2	0.85
RELATIVE RISK	0.89

	INJURY	NO-INJURY	ROW TOTAL
3.0-3.5	6	2	8
REMAINDER	22	4	26
COLUMN TOTAL	28	6	34

ROW 1	0.75
ROW 2	0.85
RELATIVE RISK	0.89

	INJURY	NO-INJURY	ROW TOTAL
4.0-5.0	5	2	7
REMAINDER	23	4	27
COLUMN TOTAL	28	6	34

ROW 1	0.71
ROW 2	0.85
RELATIVE RISK	0.84

Appendix 14: Disability Relative Risk Raw Data '

	INJURY	NO-INJURY	ROW TOTAL
SCIR	14	1	15
REMAINDER	14	5	19
COLUMN TOTAL	28	6	34

ROW 1	0.93
ROW 2	0.74
RELATIVE RISK	1.27

	INJURY	NO-INJURY	ROW TOTAL
AMP	3	1	4
REMAINDER	25	5	30
COLUMN TOTAL	28	6	34

ROW 1	0.75
ROW 2	0.83
RELATIVE RISK	0.90

	INJURY	NO-INJURY	ROW TOTAL
CP	3	1	4
REMAINDER	25	5	30
COLUMN TOTAL	28	6	34

ROW 1	0.75
ROW 2	0.83
RELATIVE RISK	0.90

	INJURY	NO-INJURY	ROW TOTAL
AB	3	1	4
REMAINDER	25	5	30
COLUMN TOTAL	28	6	34

ROW 1	0.75
ROW 2	0.83
RELATIVE RISK	0.90

	INJURY	NO-INJURY	ROW TOTAL
OTHER	5	2	7
REMAINDER	23	4	27
COLUMN TOTAL	28	6	34

ROW 1	0.71
ROW 2	0.85
RELATIVE RISK	0.84

Appendix 15: Playing Standard Relative Risk Raw Data '

	INJURY	NO-INJURY	ROW TOTAL
PREM	4	0	4
REMAINDER	23	5	28
COLUMN TOTAL	27	5	32

ROW 1	1.00
ROW 2	0.82
RELATIVE RISK	1.22

	INJURY	NO-INJURY	ROW TOTAL
DIV1	13	2	15
REMAINDER	14	3	17
COLUMN TOTAL	27	5	32

ROW 1	0.87
ROW 2	0.82
RELATIVE RISK	1.05

	INJURY	NO-INJURY	ROW TOTAL
DIV2	3	0	3
REMAINDER	24	5	29
COLUMN TOTAL	27	5	32

ROW 1	1
ROW 2	0.83
RELATIVE RISK	1.21

	INJURY	NO-INJURY	ROW TOTAL
DIV3	7	3	10
REMAINDER	20	2	22
COLUMN TOTAL	27	5	32

ROW 1	0.70
ROW 2	0.91
RELATIVE RISK	0.77

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