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movement screening and development of an efficacious exercise intervention

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Injury prevention in men's community rugby union: movement screening and development of an efficacious exercise intervention.

MATTHEW JAMES ATTWOOD

A thesis submitted for the degree of Doctor of Philosophy

University of Bath

Department for Health

June 2017

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M. J. Attwood

ABSTRACT

English men's community rugby boasts the largest adult rugby playing population in the world. While regular participation in rugby has been linked to clinical health benefits there is an inherent risk of injury associated with rugby participation due to its collision based nature. This programme of research was conducted to identify means to reduce the injury risk in the context of men's community rugby.

In Chapter 3, the Functional Movement Screen is used to assess the movement competency of men's community rugby players. Injury match exposure data was recorded for each player, and analysed to determine associations between players' movement competency and injury outcomes. Players that displayed both of pain and asymmetry on screening were associated with an incidence of overall injury at 22.0 injuries / 1000 player match-hours. Players that scored 16 or more had an incidence of overall injury at 12.4 injuries / 1000 player match-hours. Chapter 4 details the multi-stage process used to develop the injury prevention exercise programme specific to men's community rugby. Chapter 5 investigated barriers and facilitators to programme implementation in a sample of men's community rugby clubs. Results informed the refinement of the intervention exercise programme and detailed means to maximise successful delivery of the programme to clubs. Chapter 6 was a cluster randomised controlled trial of the final injury prevention exercise programme. Clear beneficial effects following implementation included a 40% reduction in targeted lower-limb injury and a 60% reduction in concussion compared to the control group. The injury burden for intervention clubs with higher compliance was reduced 50% compared to intervention clubs with lower compliance.

Functional Movement Screening™ may identify men's community rugby players at higher risk of match injury. A targeted movement control exercise programme can provide efficacious means to reduce injury that is practicable within the men's community rugby environment.

PUBLICATIONS

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CHAPTER ONE

INTRODUCTION

1.1 Research overview

The origin of rugby union is believed to date back to 1823 at Rugby school in England, when William Webb Ellis picked up the ball during a game of football and ran with it. Rugby union is a sport now enjoyed by 7.3 million people worldwide (World Rugby, 2016b). While different types of rugby are played, including touch / tag rugby, Rugby 7s, Rugby 10s, Rugby League and Rugby Union, this thesis will focus on the 15-a-side variant of the game. Rugby union (here after 'rugby') is the second most popular team sport played in the UK behind football (soccer) (Sport England, 2016), and England has the largest rugby playing population in the world with over 2 million players (World Rugby, 2016b). The majority of registered rugby players participate within the 856 English community rugby clubs.

Rugby is an intermittent team ball sport, comprising frequent high intensity bouts of exercise interspersed with periods of rest (Roberts et al., 2008). As such there are potential health benefits from participation in rugby. As a form of physical activity, rugby is recognised and recommended as a form of vigorous exercise for adults (NHS, 2015). Community rugby players typically train for around 3 hours per week and play in one 80 minute game at the weekend, thus meeting the recommendation for vigorous activity of 75 minutes per week (NHS, 2015). England Rugby promotes 'rugby for a healthy lifestyle', helping players develop core stability and improving cardiovascular ability (England Rugby, 2017). Some studies have displayed the potential health benefits of rugby using clinical outcomes. A US based cross-sectional study demonstrated that collegiate rugby players had a low risk of disease such as cardiovascular disease (MacDougall et al., 2015). Two Australian based clinical trials (Mendham et al., 2015; Mendham et al., 2014) prescribed touch rugby as a form of small sided game exercise in inactive middle aged males. Following 8 weeks of playing touch rugby, participants demonstrated significantly improved health markers. Participants had significantly improved aerobic capacity, reduced fat-mass, and reduced pro-inflammatory markers (Mendham et al., 2014) that are otherwise associated with potential development of metabolic and cardiovascular abnormalities (Bouassida et al., 2010; Arita et al., 1999) and may also help prevent type 2 diabetes (Mendham et al., 2015). On this evidence, playing rugby appears beneficial for players' health.

As well as having potential health benefits, participation in rugby carries a risk of injury (Roberts et al., 2013). Rugby is a physically demanding sport characterised by numerous physical player to player contacts (Roberts et al., 2008) that are inherent to the nature of the game. Contact events within rugby such as the tackle, rucks, mauls lineouts and scrums are associated with approximately 80% of all injuries (Roberts et al., 2013; Hughes and Fricker, 1994) and contribute to rugby having a relatively high risk of injury compared to some other team sports (Williams et al., 2013). While player-to-player contact does occur in other popular team ball sports like football and basketball, it is generally considered an infringement to the laws of the game in these sports. By definition a player should tackle the ball, not the player in both football (FIFA, 2014) and basketball (FIBA, 2014). In contrast to football and basketball, an effective tackle in rugby involves the direct contact (often considered a collision) of the defending player's shoulder and arm, to the torso of the ball carrying player (Hendricks et al., 2014).

The Rugby Football Union (RFU) is the national governing body for rugby in England, and has identified player injury as one of the top 4 reasons for players dropping out of rugby (RFU, 2011). According to an online survey completed in England by 1282 players (current players = 1261, former players = 221), risk of injury was highlighted as a main reason effecting players' future participation in the game second only to age and employment commitments. Actual injury was the main reason injured players did not return to rugby participation (England Rugby, 2014). Similarly, in a different survey of 911 players, rugby injury was the main cause for ex-players (n = 390) to retire from participation, ahead of family commitments and employment demands (Lee et al., 2001). Efforts have been made to help reduce the risk of injury from contact events and improve player safety. These include law amendments for scrummaging (World Rugby, 2015; Cazzola et al., 2014) that effect the game globally; compulsory coach and referee education courses as part of RugbySmart (Gianotti et al., 2009) in New Zealand; provision of first aid training and first aid advice as part of BokSmart (Viljoen and Patricios, 2012) in South Africa; and information and awareness campaigns such as 'recognise and remove' in relation to management of suspected concussion injuries (RFU, 2015a). However, multimodal injury prevention exercise programmes aimed at improving players' intrinsic physical characteristics have yet to be assessed in rugby.

Arguably, the most commonly cited model of sports injury prevention is the 'sequence of injury prevention' (van Mechelen et al., 1992). The sequence of injury prevention includes 4 key stages for sports injury prevention: 1) establish the extent of the problem; 2) establish the aetiology and mechanisms of injury; 3) introduce preventative measures, and 4) assess their effectiveness by repeating stage 1. In the context of stage 1 of the sequence of injury prevention, the incidence of injury in English men's community rugby has been reported to be 16.9 injuries per 1000 match hours (95%CI = 16.1 – 17.7) where the average injury severity was 7.6 (95%CI = 7.2 – 8.0) weeks per 1000 match hours (Roberts et al., 2013). Translating this into a practical situation, for every 3 team games, 1 player received an injury that caused them to miss an average of 7 matches (approximately 1/3 of the competitive season). If these values were extrapolated to men's 1st teams in all 856 community clubs, over 7100 time-loss injuries might occur per season (average season = 25 matches), resulting in over 66,500 hours of match play lost due to injury in community men's first team rugby.

With respect to stage two of the sequence of injury prevention, attempts have been made to identify injury risk factors for rugby players (Chalmers et al., 2012; Gianotti et al., 2009) where players' previous injury, hours of strenuous activity, cigarette smoking status and ethnicity were found to influence injury risk. Other risk factors include contact events such as the tackle, ruck and maul that are associated with 80% of injuries in men's community rugby (Roberts et al., 2013). However such events are innate to the game of rugby and may require a different approach to that applied within this thesis, such as video analysis to help determine the propensity for injury associated with the different contact events before making recommendations for change. An individual's functional movement competency, as identified using the Functional Movement Screen™, has also been associated with player's risk of injury in professional (Tee et al., 2016) and experienced (Duke et al., 2017) rugby players. However, the association of functional movement and injury risk has not been investigated within a men's community rugby setting, warranting further investigation.

Stage three of the sequence of injury prevention, the introduction of preventative measures (van Mechelen et al., 1992), has been attempted in rugby through means of law changes, and education programmes as described previously, but not through exercise programmes tailored for rugby injuries, which could provide an effective means of reducing injury rates. By targeting the most common rugby injuries in the large population that forms men's community rugby the overall injury burden may decrease dramatically across the men's community game, aiding player welfare, player retention within the game and maintain player's enjoyment of the game of rugby. Injury rates for sports other than rugby have been shown to be modifiable through exercise interventions that include proprioception, balance, strength and movement co-ordination exercises (Aaltonen et al., 2007; Hubscher et al., 2010; Herman et al., 2012; Gilchrist et al., 2008; Olsen et al., 2005). Consequently, increased attention has focussed on exercise-based injury prevention programmes, with the most researched programme being the FIFA 11+ (Soligard et al., 2008) which was designed specifically for football. Due to the context of previous studies having investigated the preventative effect of exercise programmes in females rather than males (Gilchrist et al., 2008; Soligard et al., 2008; Steffen et al., 2013), soccer (Gilchrist et al., 2008; Soligard et al., 2008; van Beijsterveldt et al., 2012 Steffen et al., 2013; Hammes et al., 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015) or basketball (Longo et al., 2012) rather than rugby, research of exercise programmes to reduce injury in men's community rugby is warranted. As differences such as gender (male / female) and sport (soccer / basketball / rugby) influence the aetiology of injuries due to altered internal and external injury risk factors, research specifically focussing on men's community rugby is warranted. While there is evidence supporting implementation of exercise programmes for injury prevention in other sports, currently there is no evidence that demonstrates the efficacy of an exercise programme for injury prevention in men's community rugby. By targeting physical attributes including proprioception, balance, strength and movement co-ordination exercises will likely help players resist injury. For example, by improving players' proprioception, players may be better able to react to unexpected perturbations, and maintain good posture and lower-limb kinematics. As such, an exercise warm-up intervention will be trialled in men's community rugby, aligned with step 3 of the sequence of injury prevention (van Mechelen et al., 1992).

The Community Rugby Injury Surveillance and Prevention (CRISP) project has conducted injury surveillance across men's community rugby clubs since 2009. As men's community rugby represents a significant proportion of the rugby playing population in England, men's community rugby is an ideal population to target the reduction of injuries. Based on the aforementioned information, a series of studies were funded by the Rugby Football Union, the Private Physiotherapy Education Fund and the University of Bath to investigate the association of functional movement and injury risk in men's community rugby, prior to developing, implementing and assessing the efficacy of an injury prevention exercise programme for men's community rugby.

This series of studies will provide evidence that has the potential to inform practice and help reduce the injury burden within the sport. The aim of this research is to provide practitioners working in men's community rugby, such as registered health professionals that provide medical support; strength and conditioning coaches and rugby coaches that both help develop the physical characteristics of players, evidence to justify the use of the Functional Movement Screen ™ as a movement screening tool and to produce programme of warm-up exercises that are efficacious in reducing the burden of match-injury.

Accordingly, the following research questions will be investigated:

1. Is there an association between men's community rugby players' functional movement competency, as determined using the Functional Movement Screen, and risk of injury?

2. What stages are involved in the development of a movement control exercise programme to reduce injury in men's community rugby?

3. What influences the implementation of structured warm-up exercise programmes in men's community rugby?

4. What is the efficacy of a movement control injury prevention programme in men's community rugby?

1.2 Thesis overview

1.2.1 Chapter 2: Literature review

Chapter 2 is a review of literature pertinent to the aforementioned research questions. This includes literature regarding the injury profile of men's community rugby along with potential risk factors for those injuries; the use of the Functional Movement Screen™ as a tool to assess athlete's injury risk across different sports; potential means to prevent injury in rugby; and literature related to sports injury prevention by targeted exercise programmes.

1.2.2 Chapter 3: Association of the Functional Movement Screen with injury outcome in men's community rugby union.

An investigation into the association between player's pre-season Functional Movement Screen™ performance and injury risk is presented in Chapter 3. Injury incidence was calculated before Poisson regression analysis was performed to determine associations between FMS composite score, FMS movement asymmetry and reports of pain, with injury risk. [RESEARCH QUESTION 1].

1.2.3 Chapter 4: Developing a movement control injury prevention exercise programme.

Chapter 4 is a narrative summary that provides insight into the process driven approach adopted during the development of a movement control exercise programme. Chapter 4 provides a description of the multiple factors that influenced the final programme design before programme implementation during a large scale randomised controlled trial. [RESEARCH QUESTION 2].

1.2.4 Chapter 5: Facilitators and barriers to implementing structured warm-up programmes in men's community rugby union.

Forming one of the steps toward the development of a movement control exercise programme, a pilot study was performed. Club representatives involved in the delivery of the programmes within their clubs were interviewed to determine facilitators and barriers to implementation within the context of men's community rugby. [RESEARCH QUESTION 3].

1.2.5 Chapter 6: Efficacy of a movement control injury prevention programme in men's community rugby union: a cluster randomised controlled trial.

A cluster randomised controlled trial was conducted to determine the injury prevention effect of a movement control exercise programme in men's community rugby. The prevention programme targeted the head and neck, shoulder and lower-limb and was compared to a control programme that represented 'good practice'. Cluster adjusted Poisson regression analysis was used to calculate the relative risk of injury and results were interpreted using magnitude based inference. [RESEARCH QUESTION 4].

1.2.6 Chapter 7: General discussion

A discussion of the primary findings and conclusions of this thesis are presented in Chapter 7. The approach implemented throughout the thesis, and the contribution to existing knowledge are discussed. The practical implications of the findings and future research are suggested.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter provides a summary of the literature pertinent to the series of experimental chapters within this thesis. Initially, key models of sports injury prevention are compared, highlighting the need for context specific implementation strategies which are essential for effective injury prevention. The extent of the injury problem in men's community rugby is summarised from existing injury surveillance literature and prominent injury risk factors are discussed. Evidence supporting the use of the Functional Movement Screen^{TM} as a pre-season assessment of injury risk is summarised, justifying its application in men's community rugby in Chapter 3. Existing strategies for injury prevention in rugby and the efficacy of movement control exercise interventions in other sports is summarised. The aim of this chapter is to provide clear justification for undertaking this injury prevention research in men's community rugby.

2.2 Injury prevention models

There are two widely recognised models of sports injury prevention, the sequence of injury prevention (van Mechelen et al., 1992) and Translating Research into Injury Prevention Practice (TRIPP) (Finch, 2006). Both models are based on injury surveillance, identification of risk factors for injury, and the implementation and evaluation of injury prevention strategies. The sequence of injury prevention comprises these four steps (van Mechelen et al., 1992) (Figure 2.1) and was a modified version of a public health prevention model (Robertson, 1992).

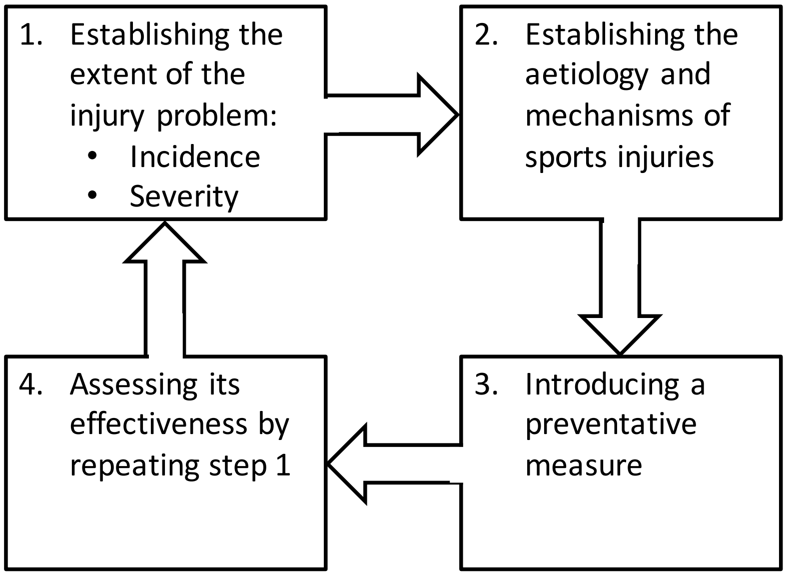

Figure 2.1. The sequence of injury prevention (van Mechelen et al., 1992).

The sequence of injury prevention clearly outlines processes whereby an evidence base for sports injury epidemiology must be established along with causative factors for those injuries before an injury prevention measure can be rationally implemented. However, the sequence of injury prevention model does not consider the need for research regarding implementation issues, such as factors effecting compliance and adherence to prevention measures. The issue of poor programme compliance influences the effectiveness of prevention measures (TRIPP stage 6) (Steffen et al., 2013), and may also result in the inability of a trial to determine the efficacy of programmes in the first instance (TRIPP stage 4) (Soderman et al., 2000; Steffen et al., 2008). The direction required for research that leads to direct injury prevention in real world settings is considered under the more recent model; Translating Research into Injury Prevention Practice (Finch, 2006)(Figure 2.2).

Model stage	TRIPP
1	Injury Surveillance
2	Establish aetiology and mechanisms of injury
3	Develop Preventative measures
4	"Ideal conditions" / Scientific evaluation
5	Describe intervention context to inform implementation strategies
6	Evaluate Effectiveness of preventive measures in implementation context

Figure 2.2. The 'Translating Research into Injury Prevention Practice' framework for research leading to real world sports injury prevention (Finch, 2006).

The TRIPP model's two additional stages (stage 5 and stage 6) consider the efficacy of prevention measures from a controlled environment, such as within the constraints of a research study, and how to translate efficacious means of injury prevention to the context it was intended for, i.e., in 'real world' settings (Finch, 2006).

To understand the problem (stage 1 of TRIPP) (Finch, 2006), research describing the injury occurrence of injury in men's community rugby may be summarised from appropriate literature where this is available, taking care to ensure standardised sports injury and exposure definitions are used (Chalmers, 2002; van Mechelen, 1998). For rugby, focus should be drawn to epidemiological research that defined injury in accordance with the rugby injury consensus statement (Fuller et al., 2007a). To understand the aetiology of why rugby injury occurs (stage 2 of TRIPP) (Finch, 2006), the mechanisms of injury and factors associated with injury causes and severity of injury must then be established (Finch, 2006). As injury surveillance cannot directly establish the mechanism of injury, sports medicine approaches including those with multidisciplinary, biomechanical and clinical focus are needed to better understand risk factors for and mechanisms of injury (Krosshaug et al., 2005) and identify potential strategies that may be effective in reducing injury. Using this information TRIPP stage 3 (Finch, 2006) involves the development of the preventative measures. Little research is available specifically detailing this step in a sports context, and as such theory must be applied from a health context where processes for development and evaluation of complex interventions has been outlined (Craig et al., 2008). During the development of prevention measures, development stages proposed include development, feasibility and piloting, evaluation and implementation (Craig et al., 2008). The two stages, 'development' and 'feasibility and piloting', reflect the means by which stage 3 of the TRIPP (Finch, 2006) model can be achieved. Although the TRIPP model clearly outlines a series of logical steps, in practice these may not follow a linear or cyclical sequence, rather, optimisation and evaluation via feasibility trials inform the decision whether to proceed to a randomised controlled trial (i.e., TRIPP step 4) (Campbell et al., 2007).

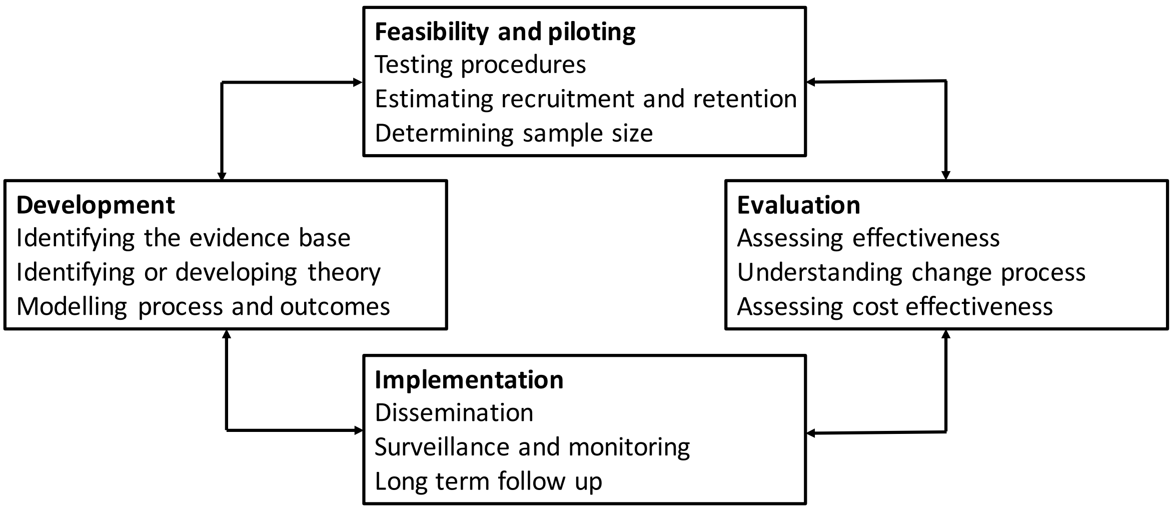

Figure 2.3 Key elements of the programme development and evaluation process (Craig et al., 2008).

Stage 4 of TRIPP corresponds to intervention efficacy assessment (Finch, 2006). Stage 4 is an 'ideal conditions' evaluation of the preventative measures produced during stage 3. Irrespective of how 'hands off' a research team is, the knowledge of participation in a study can influence participants' behaviour. For example club delegates may use a programme they consider to be terrible, which they would not otherwise use, apart from knowing they are being monitored. For this reason, the TRIPP (Finch, 2006) model includes two stages not considered within the sequence of injury prevention (van Mechelen et al., 1992). The two additional stages are the translation of the evidence supporting the intervention to the context it was intended (stage 5 of TRIPP) and subsequently to evaluate the effectiveness of the intervention in a real-world, 'hands-off' setting (stage 6 of TRIPP) (Finch, 2006).

The primary considerations of this thesis reflect stage 2 through to stage 4 of the TRIPP model (Finch, 2006) in the context of men's community rugby. The following sections of this literature review will discuss existing research informing the process of injury prevention in men's community rugby union.

2.3 STAGE 1: Injury surveillance

The first stage of the models of injury prevention involves injury surveillance to establish the extent of the injury problem. Injury epidemiology is the study of how often injuries occur, dealing with the incidence, distribution and possible control of factors relating to those injuries (Stevenson, 2010). In England, men's professional rugby injury surveillance has been conducted since 2002 (Williams et al., 2015) while men's community rugby injury surveillance has been ongoing since 2009 (Roberts et al., 2013). Such information provides an overview of the rate and severity of injury including the distribution of injuries across the body and the tissues prone to injury, which is necessary when planning to implement means of injury prevention.

2.3.1 Injury definition

While there is a reasonable body of literature evidencing injuries in community rugby union, the injury definitions used have been inconsistent. As such, inter study comparisons of injury rates across studies are very difficult. The array of rugby injury definitions also limits the cross comparison to other popular mass participation ball sports such as football. Examples of rugby union injury definitions includes: any injury that required the referee to stop play (Kauffman, 1985); the presence of pain, discomfort or disability arising during and as a result of playing in a rugby match (Addley and Farren, 1988); a 'significant injury' was an injury that prevented a player from playing or training or that required 'special medical treatment' (Hughes and Fricker, 1994); an injury that caused the player to miss at least one game or scheduled team practice, or to seek medical attention (Quarrie et al., 2001); and an injury that occurred during active rugby participation in either a structured or unstructured environment that necessitated admission to an accident and emergency department (Yard and Comstock, 2006). This list is not exhaustive. These definitions lack the consistency necessary for performing a meta-analysis or similar comparison of data. Finch, 1997) reported the need for standardised methodologies and definitions to common aspects of surveillance investigations. In 2007, a consensus statement for injury reporting in rugby union was published (Fuller et al., 2007a).

The International Rugby Board (now World Rugby) consensus statement defines an injury as: any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity… sustained by a player during a rugby match or training, irrespective of the need for medical attention or time-loss from rugby activities (Fuller et al., 2007a). The operational definition used must also be consistent to enable comparison between studies and may include: training/match injury; medical attention or time-loss injury (whereby time-loss injury severity is expressed as time (days) lost form competition and practice), and type of injury, classified by 6 main groupings (bone, joint and ligament, muscle and tendon, skin, brain/spinal cord/peripheral nervous system and other).

2.3.2 Community rugby injury epidemiology

Three studies have reported the injury epidemiology of men's community rugby post the 2007 consensus statement (Swain et al., 2016; Roberts et al., 2013; Schneiders et al., 2009). Using a match-injury definition of any injury incurred during match play, that resulted in medical attention or time-loss from training or match play, injury surveillance of 10 New Zealand based men's community rugby clubs was conducted over the course of one competitive season (Schneiders et al., 2009). The overall injury incidence was 52 (95%CI = 42-65) injuries / 1000 player match-hours, where 37% of injures were medical attention injuries and 63% were time-loss injuries (Schneiders et al., 2009). Of the 164 injuries reported, 48% resulted in >7 day time-loss (injury incidence rate = 25.2 (95%CI = 20.2-31.4) injuries / 1000 player match-hours) and six injuries resulted in permanent retirement from playing rugby (Schneiders et al., 2009). The shoulder (14% of all injuries), knee (14% of all injuries) and ankle (8% of all injuries) were the most commonly injures joints and haematoma/bruising (21%), ligament tears/sprains (21%) and muscle tear/strains were the most common types of injury (Schneiders et al., 2009).

In a report of match injuries to amateur players (n = 125) from one Australian rugby club, the overall time-loss injury incidence was 52.3 (95% confidence interval (CI) = 3.7-62.2) injuries / 1000 player match-hours, where 36% of all injuries resulted in players missing at least 1 week from training and match play (Swain et al., 2016). In this study the top 3 sites of injury were the head and face (17.8%), followed by the shoulder/clavicle (14%) and knee (14%). The top 3 types of injury included ligament sprains (27%), haematoma/contusion/bruise (19%) and muscle/tendon (17%) injury (Swain et al., 2016). The incidence of injuries resulting in >7days time-loss was 18.7 (95%CI = 14.0-24.9) injuries / 1000 player match hours. This incidence is lower than that observed in the New Zealand based players (Schneiders et al., 2009) and just above the incidence reported in English community rugby (Roberts et al., 2013). An average of 63 clubs completed surveillance over 3 seasons in England where the overall incidence of injury (> 7 days) was 16.9 (95%CI = 15.2-17.9) injuries / 1000 player match-hours (Roberts et al., 2013). Further similarity between studies includes the most commonly injured joints which for the English clubs was the knee (17%), shoulder (14%) and ankle (12%), and the top two types of injury which were joint/ligament injury (22%) and muscle/tendon injury (15%) (Roberts et al., 2013). The difference in proportion of injuries that were contusion / haematoma between studies (21% & 19% : [Schneiders et al., 2009; Swain et al., 2016] vs. 1%

[Roberts et al., 2013]) is likely the result of differences in resolution of time-loss of injuries used between the studies. Roberts et al., (2013) used a minimum time-loss resolution of moderate injury (>7days) compared to slight injury (0-1 day) used by Swain et al., (2016) & Schneiders et al. (2009). Muscle and ligamentous injuries frequently require periods of greater than 1 week to repair, explaining the similarity in the proportions of the injuries types reported between the studies by Roberts et al (2013) and Schneiders et al., (2009), while cuts and bruises likely required less than 1 week to resolve and so weren't captured by Roberts et al., (2013) but were captured by Swain et al., (2016). The difference in time-loss injury resolution between the studies may also explain the vast difference in mean severity of injuries which was 9 days (Swain et al., 2016), compared to 7.6 weeks (53 days) (Roberts et al., 2013). Mean severity was not presented for the New Zealand teams (Schneiders et al., 2009). Despite similarities between the three studies, a stark difference is the injury burden. The injury burden was 470 days time-loss / 1000 player match hours (Swain et al., 2016) compared to 899 days time-loss / 1000 player match hours (Roberts et al., 2013). Effectively, the burden of match injury reported for English men's community rugby was almost twice that of an Australian men's amateur rugby club. Almost two thirds of injuries reported resulted in less than 1 week of time loss for the Australian club (Swain et al., 2016). As injuries requiring less than 1 week time-loss were not reported for English men's community rugby, the true burden for English men's rugby could be substantially higher than 899 days / 1000 player match hours.

Despite differences in the definition of injury used, the injuries detailed across studies (Table 2.1) of injury epidemiology in men's community rugby demonstrates a reasonably consistent injury profile when presented as percentage across different body sites. Figure 2.4 displays a summary of the distribution of injuries across the body according to the details published for men's community rugby.

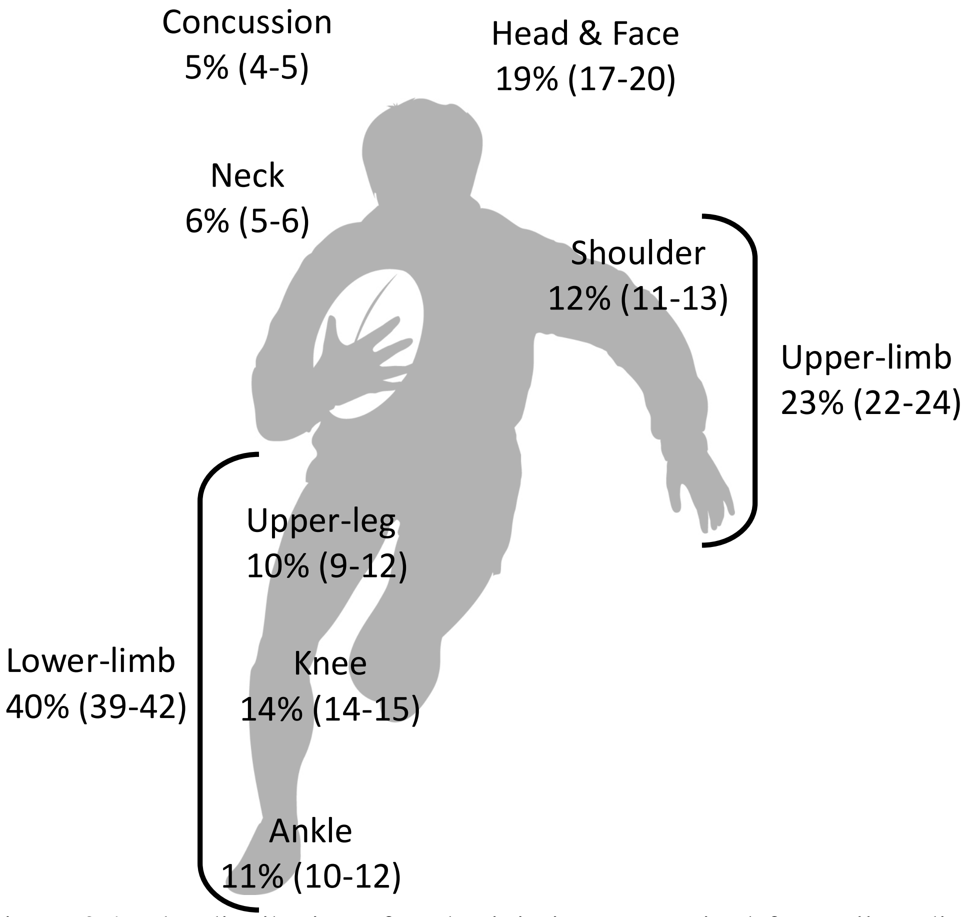

Figure 2.4. The distribution of rugby injuries summarised from all studies in Table 2.1. Values for the ankle, knee, upper-leg, shoulder, neck, concussion, head and face represent the average percentage of all injuries and 95% confidence interval. Percentages for the lower-limb and upper-limb represent the sum of their component parts. 'Other' injuries accounted for ~7% of all injuries, but were not reported under a consistent injury-site definition for comparison – as such the percentages displayed do not total 100%.

Table 2.1 Summary of men's community rugby injuries. The table details the number of injuries reported in each study and the per cent of injuries by heading.

			Percentage of all injuries									
Authors	Participants	Injuries (n)	Head & face	Concussion	Neck	Lower-limb	Upper-leg (thigh)	Knee	Lower-leg (calf)	Ankle	Upper-limb	Shoulder
Roy, 1974	SA University	300	21	3				15		14		4
Adams, 1977	'Sought medical care'	1000	9	2				11		7		1
Kauffman, 1985	English tournament	48	28	0		36					17	
Addley and Farren, 1988	Men's Club	84	16	4		36					27	
Ryan and McQuillan, 1992	Attended A&E	242	24	4	9	27					33	10
Seward et al., 1993	AUS elite level	2398	25	5		34					20	
Hughes and Fricker, 1994	AUS first grade	122	17	4	7	48	14	11	11	8	17	12
Garraway and Macleod, 1995	Scotland Senior club	429		6		42		17		6	22	11
Bird et al., 1998	Men's club	258	18	5	7	43					24	
Marshall et al., 2002	New Zealand Club	313	26	5	7	40	11	13	7	8	22	9
Yard and Comstock, 2006	Attended A&E (US)*	236539	32	3	2	24	1	9	3	9	30	14
McIntosh and Dutfield, 2008a	AUS Grade & Country	381	6	3	4	51		17		12	27	20
Kerr et al., 2008	Men's collegiate	447	30	13	3	35	5	13	2	11	25	13
Schneiders et al., 2009	NZ Premier club	164		6		36		14		8	19	14
Takemura et al., 2009	Japanese collegiate	45	22	**	7	56	11	11	2	22	7	2
Roberts et al., 2013	Men's community	1566	12	7	4	37		17		12	16	14
Farnan et al., 2013	Men's collegiate	51	4		6	48	20	14	2	12	34	26
Jaco and Puckree, 2014	SA Academy	117	7			55		25		21	22	15
Swain et al., 2016	AUS amateur club	129	18	5	5	36	9	14	5	8	30	14

*87% of data were related to male players, of which 86% were older than 18 years; **concussion was reported but combined with soft tissue facial injury, so not included. SA = South Africa, AUS = Australia, NZ = New Zealand

The lower-limb is the most commonly injured body region sustaining 40% of all injuries, followed by the upper-limb with 23% (Figure 2.4). When considering injuries by anatomical site, the distribution across the knee, shoulder, ankle and upper-leg is similar, ranging from 14% of injuries for the knee, to 10% of injuries for the upper-leg (Figure 2.4). The injuries diagnoses reported are predominantly muscle and tendon strains for the upper leg, a combination of muscle/tendon strains and ligament/joint sprains for the ankle and shoulder, and ligament/joint sprains for the knee. For English men's community rugby, the top five specific injuries were knee ligament/joint (14%, [injury incidence rate (IIR), 95%CI = .4, 2.1-2.7]), ankle ligament/joint (10%, [IIR, 95%CI = .7, 1.4-2.0]), shoulder ligament/joint (10%, [IIR, 95%CI = 1.7, 1.4-1.9), hamstring strains (10%, [IIR, 95%CI = 1.4, 1.2-1.7]), and concussion (7%, [IIR, 95%CI = 1.2, 1.0-1.4]) (Roberts et al., 2013).

An average of 18% of all rugby injuries were to the head and face, of which 60-80% were reported as contusion's and lacerations (McIntosh et al., 2008) caused by an external force, such as during a clash of heads. Blunt force trauma such as a clash of heads, may also result in head and facial fractures, which accounted for 15% of head and facial injuries (Roberts et al., 2016). In the context of head injuries, an injury receiving increased attention across all sports is concussion. Concussion is commonly reported as a specific diagnosis in rugby epidemiology papers (concussion was reported as a diagnosis in 16 of the 19 studies in Table 2.1). For English men's community rugby, concussion was the most frequent head injury diagnosis, accounting for 60% of all head related injury (Roberts et al., 2016). A meta-analysis of concussion in rugby union reported the incidence of 2.1 concussions / 1000 player match hours for men's community rugby (Gardner et al., 2014), which indicates concussion is the most common rugby injury diagnosis. There is currently no way to actively treat concussion. Concussion often requires extended periods of mental and physical rest to facilitate recovery (NHS., 2014). However, concussion in rugby is under increased media scrutiny, where some high profile cases have linked concussion to mental health (Dean, 2014), amid speculation that concussion may increase the risk for the development of degenerative disorders including dementia, though scientific evidence to support these views is limited (McCrory, 2011).

2.4 STAGE 2: Establish aetiology and mechanisms of injury

The second stage in the sequence of injury prevention involves establishing the cause or mechanism of injury and identifying risk factors for injury (van Mechelen, 1992). Risk factors may be intrinsic to the athlete (unique to an individual), or extrinsic (environmental).

2.4.1 Intrinsic risk factors

Intrinsic injury risk factors identified for community rugby players include athletic performance characteristics such as better push-up ability, aerobic and anaerobic performance, previous injury (Quarrie et al., 2001), playing while injured (Chalmers et al., 2012), age and ethnicity (Chalmers et al., 2012), anthropometric variables including body mass index (Lee et al., 1997; Quarrie et al., 2001) and movement competency (Tee et al., 2016; Duke et al., 2017).

Previous injury

Previous injury is often associated with increased risk of injury. This increase in risk may be due to the previous injury having not fully recovered before players are exposed to match-play which may result in re-occurrence of the same injury. In New Zealand, amateur players who reported a pre-season injury had a higher incidence rate than players who had no injuries during the previous season (relative risk (RR), 95%CI = 2.4, 1.3-4.3) (Quarrie et al., 2001). Similarly, in Scotland, professional players who had been injured (odds ratio (OR), 95%CI = 1.8, 1.3-2.5) or players who were carrying an injury at the end of the previous season (OR, 95%CI = 1.4, 1.0-2.1) had a 61% relative increase of injury (95%CI = 32%-97%) the following season (lee et al., 2001). For amateur players, playing while injured was also associated with increased risk of injury (RR, 95%CI = 1.5, 1.2-1.8) (Chalmers et al., 2012). Overall injury risk has also been demonstrated to increase following incidence of concussion. In a two season long study of professional players, players that returned to play within the same season following a concussion had a 60% greater risk of time-loss injury compared to players that did not suffer concussion (Cross et al., 2015). Following injury, subsequent increased risk of injury has been demonstrated across sports and is the most consistently reported risk factor for injury.

Athletic performance

Athletic performance may be associated with injury risk, for example where better athletic performers may be more resilient to injury, due having greater strength and faster recovery rates. Fatigue was suggested as a risk factor for injury during games (Brooks et al., 2005a), thus fitter players that have better recovery rates may fatigue less during a match, and consequently maintain biomechanically correct techniques during cutting, landing and contact based tasks, compared to players with lower fitness levels. Conversely, players with higher fitness levels may be able to maintain their rate of play longer and thus make more tackles. As the tackle was associated with 50% of all injuries (Roberts et al., 2013), increasing players' fitness could actually increase the risk of injury rather than decreae it. As an example of a similar effect, investigation into the risk of injury in relation to athletic performance identified players 30-m sprint time as being associated with injury risk, with no association between injury risk and any of the other athletic performance tests that included aerobic endurance, anaerobic endurance, vertical jump height and push-ups (Quarrie et al., 2001). In this instance a higher incidence rate was reported for players in the fastest group (<3.76 seconds) during a 30-m sprint from a 5-m running start compared to players in the slowest group (>4.06 seconds) (RR, 95% CI = 1.5, 1.0-2.3) (Quarrie et al., 2001). The higher injury incidence rate for the faster players may be due to the faster players entering into contact situations, such as the tackle, at higher speed thus producing a bigger collision force, which results in a higher risk of injury. Additionally, faster players may overload the knee joint during fast paced cutting manoeuvres, again resulting in a higher risk of injury. As improving strength may result in an improvement in sprint speed (Delecluse, 1997), due to increased muscle force production following intervention, rather than decrease the risk of injury due to stronger muscles having greater resilience to injury, the carry-over of muscle strength resulting in greater speed of players when entering into contact events has the potential to increase the risk of injury, i.e., resulting in the opposite effect to that which was wanted.

Anthropometric variables

The media often speculates that rugby players are getting bigger, where media articles relate increases in player stature to increased risk of injury (Kitson, 2015). However, a review of data collected over 10 years detailing the stature of English professional players indicated that while there are differences in the anthropometric characteristics between backs and forwards, over the 10 year period, anthropometric characteristics have shown little change (Fuller et al., 2013). Studies that investigated injury risk and anthropometric characteristics identified that players whose body mass was greater than 81 kg were associated with a higher injury rate than players whose body mass was under 74 kg (Quarrie et al., 2001). Specifically, players with a body mass between 81 kg and 87 kg had a higher incidence rate (RR, 95%CI = .8, 1.1-2.9) and greater injury burden (RR, 95%CI = 1.9, 1.0-2.1) than players with body mass under 74 kg (Quarrie et al., 2001). In the same study, players with a body mass index between 26.5 – 28.0 kg/m^2 sustained more injuries than players with a body mass index of less than 23 kg/m^2 (RR, 95%CI = 2.0, 1.2-3.3), as did players with a body mass index greater than 28 kg/m^2 (RR, 95%CI = 1.8, 1.1-3.0) (Quarrie et al., 2001). The association of BMI with injury risk reflects earlier research that also reported players with higher body mass index had a greater risk of injury compared to players with lower body mass index (Lee et al., 1997). A difficulty when assessing anthropometric data is that changes in mass and body mass index don't necessarily reflect changes in composition of the body, particularly that of fat mass and muscle mass. Within rugby, players are also often designated a playing position based on their physique, and this external factor may have a large influence on their risk.

Eccentric hamstring strength

Of the non-contact injuries, hamstring strains accounted for 54% of running injuries (Roberts et al., 2013) with an overall incidence of 1.9 injuries / 1000 player match-hours. Risk of hamstring injury is potentially related to underlying functional deficits in the players who sustained injury. Risk factors investigated for hamstring injury in professional rugby players included players' age, height, body mass, body mass index and ethnic origin but results indicated these factors were not associated with increased risk of hamstring injury (Brooks et al., 2006). However, in the same study a most likely beneficial lower hamstring injury rate was observed in players that performed Nordic hamstring exercises in addition to conventional stretching and strengthening exercises, compared to players who performed conventional strengthening exercise alone (RR, 95%CI = 0.4, 0.2-0.6). While hamstring strength has not been identified as a risk factor for injury in rugby, in other sports including Australian rules football, physical attributes such as increased eccentric hamstring strength have been associated with reduced hamstring injury risk (Opar et al., 2014). In this study players with lower eccentric hamstring strength at the end of pre-season were 4.7 times the risk of in-season hamstring injury, where high-speed running was the primary mechanism of injury (61% of all hamstring injuries). Collectively, this is suggestive that lower eccentric hamstring strength may be a risk factor for hamstring injury in rugby.

Movement competency

Two papers have associated movement competency, as determined using the functional movement screen to injury risk in rugby players (Tee et al., 2016; Duke et al., 2017). Players from one professional South African rugby team that became injured (mean ± standard deviation (SD) = 13.2 ± 1.5) scored significantly lower on the functional movement screen compared to players that did not become injured (mead ± SD = 4.5 ± 1.4; effect size = 0.83, *large*) (Tee et al., 2016). In a separate study on experienced rugby players in Canada, players stat scored less than 14 from a maximum of 21 on the functional movement screen were 10.4 (95%CI = 1.3-84.8) times more likely to have sustained an injury in the first half of the season compared to players scoring 14 or more (Duke et al., 2017). Due to the high association with risk, injury risk and functional movement is discussed in detail in latter sections of this literature review

2.4.2 Extrinsic risk factors

Match event

Contact events including tackles (both performing the tackle and being tackled), rucks, scrums, line-outs and mauls are associated with approximately 80% of all injuries (Addley and Farren, 1988; Hughes and Fricker, 1994; Garraway and Macleod, 1995 Roberts et al., 2013). The rugby tackle is the most frequent contact event in the rugby accounting for almost 40% of all contact events (Roberts et al., 2014). The tackle exposes the bodies of both the tackler and the ball carrier to large external forces and results in 56% of all playing and training time-loss as well as 61% of all work days lost from employment or education (Garraway et al., 1999; Garraway and Macleod, 1995).A recent analysis of the tackle event demonstrated that players who got injured during a the tackle demonstrated poor tackle proficiency for tackles made from the side/behind the ball carrier and for tackles made front on (Burger et al., 2016). As well as being the most common event, the tackle has the highest propensity for injury of 2.3 (95%CI = 2.2-2.4) / 1000 events as well as the highest severity (19 weeks missed / 1000 events). In contrast to contact events, only 20 per cent of injuries are non-contact (Roberts et al., 2013) of which running is the most common non-contact injury event (10% of all injuries) followed by twisting/turning (7% of all injuries) and hamstring strain was the most common diagnosis (5% of all injuries) (Roberts et al., 2013).

Playing level

Players in higher grades of rugby frequently demonstrate higher levels of injury (Quarrie et al., 2001; Fuller et al., 2007b; Roberts et al., 2013). In New Zealand, players at senior A level reported the highest rate of injury when compared to colts (U18/19) (Quarrie et al., 2001). In English community rugby, semi-professional (IIR, 95%CI = 21.7, 19.8-23.6) had a significantly higher incidence of injury than both amateur (IIR, 95%CI = 16.6, 15.2-17.9) and recreational players (IIR, 95%CI = 14.2, 13.0-15.4). The incidence for Professional club level rugby was 91 injuries / 1000 player match-hours (Brooks et al., 2005a, b), yet for amateur club rugby was 52.3 injuries / 1000 player match-hours (Swain et al., 2016). Potential explanations include greater physicality during contact events between players who are stronger (Brooks et al., 2005a, b). However, as the playing standard increases the ball is in play for longer periods of time in higher standards of rugby compared with lower standards Eaves and Hughes, 2003), leading to a greater number of contact events at higher levels (Roberts et al., 2014), thus more exposure to injury risk events.

Playing position

The physical demands of rugby match play can be dependent on the playing position (Duthie et al., 2006; Roberts et al., 2008). It is normal that only forward players participate in scrums and lineouts. It is also predominantly forward players that are involved in mauls. As such the physical contact and potential for injury may vary according to playing position. In terms of positional groups, a study in New Zealand saw midfield backs reported a higher injury burden (proportion of season missed) that front row forwards (RR, 95%CI = 2.6, 1.3-5.0), potentially due to midfield back entering into contact situations at higher speeds. In English community rugby, back row forwards compared to outside backs had a very likely harmful higher relative risk of injury (RR, 95%CI = 1.3, 1.1-1.5) (Roberts et al., 2013). Similar differences in injury risk were seen between the back row forwards and second row (RR, 95%CI = 1.4, 1.2-1.7), and back row forwards and front row forwards (RR, 95%CI = 1.3, 1.1-1.5) (Roberts et al., 2013). This may be due to part of the role of the back row forwards is to be as a first line of defence from scrums and to compete for the ball during rucks where back row players grapple for the ball on the floor. However, for men's community rugby, no difference in injury incidence was observed between forwards (IIR, 95%CI = 17.3, 16.1-18.5) and backs (IIR, 95%CI = 16.5, 15.2-17.7). Overall there does not appear to be a consistent pattern related to playing position.

Time within the season

The time within the season has been associated with increased injury risk (Quarrie et al., 2001; Garraway and Macleod, 1995; Roberts et al., 2013). In English men's community rugby, injury risk was significantly ($p<0.001$) greater early in the competitive season (during September and October) compared to later in the competitive season (all other months) (Roberts et al., 2013). The association between early season and injury may be due to players not being 'match-fit' having had too little exposure to the demands of match-play throughout the off-season and pre-season periods. This early season risk of injury may also be attributed to a sudden increase in work load associated with competitive games. However, the difference could also the results of players that have predisposing risk factors getting injured once exposed to the match environment. These 'at risk' players may become injured early in the season causing the early season rate to rise.

Player training/match load

An area of growing interest is the association between match and training loads and injury risk. Players training and match loads have been described in professional rugby union with respect to the number of games played (Williams et al., 2017) and within rugby league with respect to acute to chronic workloads (Hulin et al., 2016). In professional rugby union a likely harmful (Hazard Ratio (HR), 90%CI = 1.1, 1.1-1.2) association was found for players whose monthly match exposure increased over a short period of time (an increase of 2 standard deviations compared to the previous 30-day average) (Williams et al., 2017). While such risk has been attributed to limited recovery time during the off-season and an anti-rest culture (Cresswell and Eklund, 2006), these associations relate to the professional rugby environment, and may not reflect the community rugby environment.

Protective equipment

Changes in injury risk have been associated with the use of protective equipment (Marshall et al., 2005 ; Chalmers, 1998; Chalmers et al., 2012). Wearing a gum shield appeared to reduce orofacial injury (relative risk (RR), 95% confidence interval (95%CI = 0.6, 0.1-4.6) (Marshall et al., 2005) while the wearing of head gear tended to reduce injury to the scalp and ears (RR, 95%CI = 0.6, 0.2-1.9) (Marshall et al., 2005). However, wearing a head guard has also been associated with higher rates of overall injury (RR, 95%CI = 1.23, 1.0-1.5) (Chalmers et al., 2012), possibly as a result of changes in players' perceptions and attitudes toward risk taking during a game due to feeling protected. While the use of head gear can reduce the impact forces to the brain, this does not translate to a reduction in concussion incidence (McCrory et al., 2009). Although a meta-analysis of evidence for mouth guard use in preventing sport related concussion suggested a trend toward a preventive effect in collision sports (McCrory et al., 2017), overall protective equipment does not appear effective in reducing the overall risk of injury.

The above sections summarise rugby injury risk factors. These require different approaches in order to establish a meaningful reduction of injury risk. Recommendations may be made to staff at the professional level to carefully monitor and limit potentially harmful changes in training load, while limits for the number of matches played is already in place at the elite player squad level 32 matches (Aylwin, 2016; Premiership Rugby, 2016), and age grade rugby (RFU regulation 15: RFU, 2015b) in England. Extrinsic risk factors that involve game elements such as the tackle, collision tackle (an illegal tackle without the use of arms) and player management around concussion may be influenced through game directives. Community rugby clubs coaching and medical teams have little potential to influence these extrinsic risk factors, however, intrinsic factors may be monitored or screened for by club staff, facilitating implementation of preventative measures.

Pre-participation screening

Pre-participation screening is referred to by different terms including pre-participation examination (ACSM, 2011), physical examination (McKeag, 1985), and health evaluation (Ljungqvist et al., 2009). Crudely, the main purpose of pre-participation screening is to screen for injuries, medical conditions, or other factors that may place a player at risk of safe participation (Ljungqvist et al., 2009). Screening may fulfil institutional legal and insurance requirements, assure coaches that players enter the season with some common level of health and fitness, provide the medical team with the opportunity to discover treatable conditions that might interfere with or be worsened by playing, and may aid in preventing/predicting future injuries (Maffey and Emery, 2006; Wingfield et al., 2004). Screening is compulsory before participation in sports including rugby in some countries, including Italy, to meet insurance requirements (FIR, 2016). In Italy, compulsory pre-participation screening is primarily concerned with cardiac function. Neither cardiac nor any other form of pre-participation screen is currently compulsory in the UK partly due to vastly different public health provision. Cardiac screening is required by the sporting bodies including Fédération Internationale de Football Association (FIFA) and Union of European Football Associations (UEFA)(Borjesson and Dellborg, 2011) and recommended by the World Rugby (formerly the international Rugby Board) that published screening guidelines in 2012 (McCarthy, 2012). Results of a nationally implemented cardiac screening programme in elite rugby players in England (Ghani et al., 2016) demonstrated that the cost of screening was £50 per player (£29,938 per condition identified). Such screening may be prohibitively costly for community clubs to introduce but is potentially useful in elite athletes.

In England pre-participation screening is common in professional rugby union clubs (Fuller et al., 2007b). A survey of existing practice indicated all participating premiership rugby clubs in England performed a musculoskeletal (MSK) pre-participation screen, with 89% of UK clubs also conducting a general health pre-participation screen as part of their pre-employment checks (Fuller et al., 2007b). Approximately 73% of division 1 rugby clubs also indicated they ran preseason MSK pre-participation screen during the pre-season (Fuller et al., 2007b). Ordinarily pre-participation screens are conducted by a multi-disciplinary team including Doctors, Physiotherapists and Strength and conditioning coaches (Fuller et al., 2007b) and use variations of the elite athlete screen such as that proposed by Brukner and Khan (2012) which consists of previous medical history questionnaires combined with cardiac and blood serum screens with varying focus on an athlete's function. Due to the resources necessary to conduct an in-depth pre-participation screen, criteria such as cost, time, seriousness of the problem, the chances of a significant finding, available personnel and equipment needs all require consideration before determining which tests to perform (Kibler et al., 1989). Within the community rugby setting, clubs do not have the contact time with medical personnel such as physiotherapists, or resources to conduct in-depth screening as described by Fuller et al. (2007b). However, the Functional Movement Screen™ (FMS), which assesses characteristics of movement patterns described as fundamental to athletic performance (Cook et al., 2006a, b) is a relatively simple screen and has proven popularity in other field sports such as soccer where it was the most employed method of screening professional soccer players (McCall et al., 2014).

2.4.3 Functional Movement Screen™

The Functional Movement Screen™ (FMS) is a widely used (McCall et al., 2014) and commercially available musculoskeletal screening tool. Briefly, the FMS consists of seven movement patterns, each scored as 0 (pain or unable to perform the movement), 1, 2 or 3 (performing the movement perfectly), and four 'clearing' movements (Table 2.2) that screen an athlete for pain when performing the movement rather than assessing the quality or range of movement. The result of the screen is a score with a maximum total of 21 points that has been associated with an athlete's risk of injury based on their 'functional performance'.

Table 2.2. The seven test items of the FMS including clearing tests (Cook et al., 2006a, b; Hammes et al., 2016).

	Description	Score	Scoring criteria
1. Deep squat	A dowel is placed over the head, arms are outstretched and the player is asked to squat as low as possible.	3	-Upper torso is parallel with tibia or toward vertical, femur is below horizontal, knees are aligned over feet, dowel aligned over feet
		2	-As above, but a 2 x 6" board is required under feet
		1	-Upper torso is not parallel with tibia or toward vertical, femur is not below horizontal, knees are not aligned over feet, lumbar flexion is noted, 2 x 6" board is required under feet
2. Hurdle step	The player aims to step over a hurdle that is placed directly in front him; a dowel is placed across the shoulders.	3	-Hips, knees and ankles remain aligned in the sagittal plane, minimal to no movement is noted in the lumbar spine, dowel and string remain parallel
		2	-Alignment is lost between hips, knees and ankles. Movement is noted in lumbar spine. Dowel and string do not remain parallel
		1	-Contact between foot and string occurs. Loss of balance
3. In-line lunge	A dowel is placed at the bodies' back side (contacting head, back and sacrum, the player aims to perform a split squat).	3	-Dowel contacts remain with lumber spine extension. No torso movement is notes. Dowel and feet remain in sagittal plane. Knee touches board behind heel of front foot.
		2	-Dowel contacts do not remain with lumbar spine extension. Movement in torso is noted. Dowel and feet do not remain in sagittal plane. Knee does not touch behind heel of front foot.
		1	-Loss of balance is noted

Table 2.2. The seven test items of the FMS including clearing tests (Cook et al., 2006a, b; Hammes et al., 2016).

	Description	Score	Scoring criteria
4. Shoulder mobility	The player attempts to touch his fists behind the back.	3 2 1	-Fists are within 8 inches -Fists are within 12 inches Fists are beyond 12 inches
Clearing test	The player places his hand on the opposite shoulder and then attempts to point the elbow upward.	0	-Pain is reported for either shoulder during clearing
5. Active straight leg raise	The player aims to actively raise one leg as high as possible while lying supine with the head touching the ground.	3 2 1	-Ankle/dowel resides between mid-thigh and anterior superior iliac spine -Ankle/dowel resides between mid-thigh and mid-patella/knee joint line -Ankle/dowel resides below mid-patella/joint line
6. Trunk stability push-up	The player aims to actively raise one leg as high as possible while lying supine with the head touching the ground.	3 2 1	-Perform one repetition with thumbs aligned with top of forehead -Perform one repetition with thumbs aligned to chin -Unable to perform one repetition with thumbs aligned to chin
Clearing test	The player aims to perform a press-up in the push-up position (spinal extension).	0	-Pain is reported during the clearing test
7. Rotary stability	The player aims to assume a quadruped position and attempts to touch his knee and elbow, first on knee and elbow of the same side of the body and then on the opposite sides.	3 2 1	-Performs one correct unilateral repetition while keeping spine parallel to surface. Knee and elbow touch -Performs one correct diagonal repetition while keeping spine parallel to surface. Knee and elbow touch -Inability to perform diagonal repetition
Clearing test	At first, the player aims to assume a quadruped position, then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands remain in front of the body reaching out as far as possible.	0	-Pain is reported during clearing test.

The FMS was created based on principles of kinaesthetic and proprioceptive awareness and motor control. The FMS is suggested to require full function of the body's kinetic linking system and aims to test the kinetic chain for restriction in range of motion, highlighting differences or weaknesses in strength or proprioception and subsequent utilisation of compensatory strategies to complete the required movements (Cook et al., 2006a, b).Compensations are identified as asymmetry where the left and right sides of the body are tested independently (such as during the hurdle step, in-line lunge, active straight leg raise, shoulder mobility and rotational stability movements). Compensations are also identified when an athlete fails to complete a movement pattern due to any combination of weakness or restriction. The compensated movement pattern(s), left untreated, may be reinforced through repetition during training, leading to poor movement patterns being adopted and used autonomously. Compensatory movement patterns have been identified as risk factors for injury and may to lead to further immobility and instability (Nadler et al., 2002). Conversely, previous injury, where an individual may have originally offloaded the effected limb but not completed appropriate rehabilitation for that limb, may also lead to the suggested 'dysfunctional' movement as detected using the FMS. Cook et al. (2006a, 2006b) suggest that this may be a reason why previous injuries have been identified to be one of the more significant risk factors in predisposing individuals to further injury. Irrespective of the cause of the dysfunction, functional deficits can lead to pain, injury, and decreased performance (Cholewicki et al., 1997; Gardner-Morse et al., 1995; Battié et al., 1989). The rational, therefore, is that if the dysfunction can be identified during the FMS then players at increased risk of injury may be identified using the FMS.

A strength of the FMS is its ease of application, making it more appropriate to the community setting where resources are often limited, compared to alternative pre-participation screen performed in a professional environment (Fuller et al., 2007b). Unlike in pre-participation screen where a medical professional is necessary to conduct the screen to examine cardiac, pulmonary, and blood markers and neurological function (Brukner and Khan, 2012) the FMS may be able to be applied by a wide variety of individuals of differing medical or coaching backgrounds. To date, papers researching FMS have used a range of individuals to deliver the screen including university aged students (Shultz et al., 2013; Gribble et al., 2013; Teyhen et al., 2012) athletic trainers (Gribble et al., 2013; Onate et al., 2012) physiotherapists (Leeder et al., 2016) and accredited strength and conditioning specialists (CSCS)(Onate et al., 2012). Throughout these studies the experience of the raters in using the FMS varied also. Some raters had no experience of applying the FMS screen (Onate et al., 2012) having only read the instructions, whilst others had up to 10-years of experience applying the FMS (Minick et al., 2010). This indicates that the FMS is a screen which a broad range of individuals may be able to conduct within a community club setting.

2.4.4 Functional Movement Screen™ reliability

Seven studies have assessed raters' reliability in conducting and scoring the FMS using real-time / live application across a variety of participants (Table 2.3). Overall study results indicate that the raters of different background, including students, researchers, biomechanics, and strength and conditioning coaches performing the FMS had good to excellent reliability. In a study involving 64 active-duty service members researchers, Teyhen et al. (2012) investigated the intra-rater (between session) and inter-rater (within session) reliability of FMS as conducted by 8 novice raters (first year physical therapy students). Novice raters demonstrated excellent inter-rater within session reliability ($ICC_{2,1} = 0.76$) and good intra-rater intersession reliability ($ICC_{3,1} = 0.74$) (Teyhen et al., 2012) (Table 1). The authors also analysed individual component agreement, using weighted kappa statistic, and indicated moderate to good component reliability. The rationale provided to explain the agreement only being moderate to good was that due to the limited volume of scores outside of a rank score of '2' the component reliability was questionable. Small and zero standard deviations for data was a common occurrence as the many participants scored '2' on each task. As such, the composite score should be used rather than component scores for athlete assessment.

Table 2.3. Summary of studies assessing the reliability of composite FMS scores under live/real time testing conditions.

	Rater information		Participant information			
Study	Background	FMS training	(n)	Profile	Measure	Results (ICC, 95%CI)
Schneiders et al., 2011	Not stated	Not stated	10	Healthy students	Inter-rater	Inter-rater ICC = 0.97 (no CI).
Onate et al., 2012	2 x Strength & conditioning specialists	1 x FMS Certified, 1 x None	19	Physically active; 12 males 7 females	Intersession Inter-rater	Intersession ICC = 0.92 (no CI) Inter-rater ICC = 0.98 (no CI)
Teyhen et al., 2012	8 x physiotherapy students	20 hours of FMS training	64	Military personnel; 53 males, 11 females	Inter-rater Intra-rater	Inter-rater ICC = 0.76, 0.63-0.85 Intra-rater ICC = 0.74, 0.60-0.83
Maeda et al., 2013	1 x Physiotherapist	Physiotherapist with FMS certification	12	Healthy male students	Intra-rater	Intra-rater ICC = 0.95, 0.94-0.97

Table 2.3 (continued). Summary of studies assessing the reliability of composite FMS scores under live/real time testing conditions

	Rater information		Participant information			
	Background	FMS training	(n)	Profile	Measure	Results (ICC, 95%CI)
Smith et al., 2013	2 x physiotherapy students 1 x not stated 1 x Athletic trainer / biomechanist	One FMS certified (not stated); others varied FMS experience	19	Physically active; 10 males, 9 females	Inter-rater Intra-rater	Inter-rater: Test 1 ICC = 0.89, 0.80-0.95 Test 2: ICC = 0.87, 0.76-0.94 Intra-rater: Rater 1 ICC = 0.90, 0.76-0.96 Rater 2 ICC = 0.81, 0.57-0.92 Rater 3 ICC = 0.91, 0.78-0.96 Rater 4 ICC = 0.88, 0.72-0.95
Parenteau et al., 2014	1 x physiotherapist 3 x physiotherapy students	All 4 FMS certified; practiced FMS	28	Male ice hockey players	Inter-rater Intra-rater	Inter-rater ICC = 0.92, 0.92-0.98 Rater 1: ICC = 0.96, 0.92-0.98 Rater 2: ICC = 0.96, 0.92 - 0.98
Waldron et al., 2016	1 x not stated	Not stated	12	Elite male under 19 rugby league players	Intra-rater	Statistics not reported. Reliability assessed based on 'practically important reference value'. No CI

Both intra-rater and inter-rater reliability was found to be excellent in a study on 19 healthy physical therapy students (Smith et al., 2013). In a study using four raters with mixed abilities including (i) a student with FMS experience, (ii) a student without prior FMS experience, (iii) a non-FMS experienced Athletic training faculty member with a PhD in biomechanics and movement science, and (iv) a FMS certified rater; measurements were taken of the 19 subjects. The biomechanist, followed by the experienced and then the non-experienced student raters all had better reliability than the FMS certified rater. The range of intra-rater ICC values were all excellent having ICC = 0.91; 0.90; 0.88 and 0.81, respectively. The inter-rater reliability was also high on both testing days with ICC = 0.89 and ICC = .87 for testing days one and two, respectively.

As part of an investigation into the normative values for FMS in an active population, Schneiders et al. (2011) conducted a within-day inter-rater reliability test using a convenience sample (n = 59) of their participants and found their raters (researchers with similar experience using the FMS) to have excellent reliability for the composite score ($ICC_{3,1}$ = 0.971) and demonstrated substantial to excellent agreement (Kappa = 0.70-1.0) for the raters' component scores.

The most recent FMS reliability study was conducted using just a single rater on a cohort of 12 elite rugby league players (Waldron et al., 2016). Using Cooper's measure of absolute agreement (Cooper et al., 2007), which is a non-parametric statistical approach, results demonstrated that there was no bias between trials for the FMS, with the majority of components reaching 100% 'perfect' agreement. The authors concluded that FMS can be reliably administered to elite rugby league players by a certified strength and conditioning coach of an intermittent standard which included one year of experience using the FMS. Despite the small sample size, the use of a single rater and the application of different reliability analysis methods to all other papers, the results are none the less encouraging and continue the support for the reliability of FMS using the 21-point scale.

2.4.5 Functional Movement Screen™ and injury

The association between Function Movement Screen™ scores and injury has been investigated using prospective studies in varying sporting populations with conflicting results. The first study that investigated the association of FMS score and injury risk involved 46 Professional American Football players (Kiesel et al., 2007). Players were screened using the FMS during the pre-season and within season injuries, defined as 'any injury resulting in 3 weeks time-loss, were recorded. Receiver operator characteristic (ROC) analysis was used to determine a 'cut-off' value from the 21-point score that maximised the sensitivity and specificity of the test, from which players at risk of injury may be identified. Throughout the season 10 (22%) players were injured. Un-injured players' mean FMS score was 17.4 (standard deviation (SD) = 3.1) compared to 14.3 (SD = 2.3) for players who sustained an injury. From the ROC analysis, a cut-off score of 14 was determined as maximising the sensitivity (sensitivity = .54, 95%CI = 0.34-0.68) and specificity (specificity = .91, 95%CI = 0.83-0.96) of the FMS cut-off (OR) = 11.67, 95%CI = 2.47-54-52).

Following the study by Kiesel et al. (2007), a further 13 prospective cohort studies have investigated the FMS as a tool for identifying athletes with greater risk of injury. Research has been conducted in professional (Kiesel et al., 2014) and collegiate (Wiese et al., 2014) American football, junior hockey (Dossa et al., 2014), mixed collegiate/university sports (Chorba et al., 2010; Garrison et al., 2015; Hotta et al., 2015; Shojaedin et al., 2014 Warren et al., 2015), mixed sport high school (Bardenett et al., 2015), professional basketball (Azzam et al., 2015), experienced (Duke et al., 2017) and professional rugby union (Tee et al., 2016) and veteran soccer (Hammes et al., 2016). The results of these studies are summarised in Table 2.4.

Table 2.4. Summary of composite FMS score and injury risk research in sporting populations (adapted from Whitaker et al., 2017).

Authors	Sport	Sample	Injury definition	Reported as significant risk factors	Outcomes
Chorba et al., 2010	Collegiate athletes (mixed sports)	n = 38 18 injuries (46% players)	A MSK injury resulting from organized intercollegiate sport practice or competition that required medical attention or advice from an ATC, AT student or physician.	FMS ≤14	OR = 3.9 (1.0-15.1) $p<0.05$ Sensitivity = 0.6 (no CI) Specificity = 0.7 (no CI)
Kiesel et al., 2014	Professional American Football	n = 238 60 injuries (25% players)	MSK injury resulting in time loss from preseason practice or games	FMS ≤14	RR = 1.9 (1.2-3.0) $p<0.05$ Sensitivity = 0.3 (0.2-0.4) Specificity = 0.9 (0.8-0.9)
				Asymmetry	RR = 1.8 (1.1-2.7) $p<0.05$ Sensitivity = 0.6 (0.5-0.7) Specificity = 0.6 (0.6-0.7)
Wiese et al., 2014	Collegiate American Football	n = 144 93 injuries (65% players)	Initial MSK problem arising from organized training or game requiring medical attention and restricted participation for ≤ 1 days	None found	FMS total ≤ 12 FMS total ≤ 17 FMS total ≤ 18 No significant association
Dossa et al., 2014	Junior Hockey	n = 20 17 injuries (85% players)	A physical condition which occurred during a game or practice which resulted in the player missing ≥1 game.	None found	FMS ≤14 No significant association

Table 2.4 (continued). Summary of composite FMS score and injury risk research in sporting populations (adapted from Whitaker et al., 2017).

Authors	Sport	Sample	Injury definition	Reported as significant risk factors	Outcomes
Shojaedin et al., 2014	Collegiate athletes (mixed sports)	n = 100 35 injuries (35% players)	Not stated	FMS<17	OR = 4.7 (no p-value or CI reported) Sensitivity = 0.7 (no CI) Specificity = 0.8 (no CI)
Garrison et al., 2015	Collegiate athletes (mixed sports)	n = 160 52 injuries (33% players)	Any MSK pain complaint associated with athletic participation, that required consultation with an ATC, PT or MD and resulted in modified training for ≥24 hours or required protective splinting or taping for continued participation	FMS ≤13 FMS ≤14	OR = 9.5 (4.1-21.8) p<0.05 Sensitivity = 0.5 (no CI) Specificity = 0.9 (no CI) OR = 5.6 (2.7-11.5) p<0.05 Sensitivity = 0.7 (no CI) Specificity = 0.7 (no CI)
Hotta et al., 2015	Collegiate athletes (mixed sports)	n = 4 15 injuries (18% players)	A MSK injury that occurred during participation in track and field practice or competition that prevented participation for 4 weeks.	None found	FMS ≤14 No significant association
Warren et al., 2015	University athletes (mixed sports)	n = 167 74 injuries (44% players)	First non-contact MSK problem that resulted in medical intervention	None found	FMS ≤10 FMS ≤12 FMS ≤14 FMS ≤16 FMS ≤18 No significant associations

Table 4 continued. Summary of composite FMS score and injury risk research in sporting populations (adapted from Whitaker et al., 2017).

Authors	Sport	Sample	Injury definition	Reported as significant risk factors	Outcomes
Bardenett et al., 2015	High school athletes (mixed sports)	n = 176 39 injuries (22% players)	A MSK injury resulting from organized high school sport practice or competition that required medical attention (sought care from ATC, PT, physician or other health care provider) and was restricted from full participation ≥1 practice or game	None found	FMS ≤11 FMS ≤12 FMS ≤13 FMS ≤14 FMS ≤15 FMS ≤16 FMS ≤17 No significant associations
Azzam et al., 2015	Professional basketball	n = 34 17 injuries (50% players)	A traumatic or overuse MSK event resulting from basketball that led to time loss of ≥7 days from practice and/or games	None Found	FMS ≤14 No significant association
Tee et al., 2016	Professional Rugby Union	n = 2 26 injuries 29% injury rate**	Any injury that caused a player to be excluded from matches and/or practice for a period of 28 days or more	FMS ≤14 non-contact injury	OR = 4.3 (0.9-21.0) $p<0.05$ Sensitivity = 0.8 (0.5-1.0) Specificity = 0.5 (0.4-0.6)
				FMS ≤13 contact injury	OR = 6.5 (1.8-23.0) $p<0.05$ Sensitivity = 0.7 (0.4-0.9) Specificity = 0.7 (0.6-0.8)

Table 2.4 (continued). Summary of composite FMS score and injury risk research in sporting populations (adapted from Whitaker et al., 2017).

Authors	Sport	Sample	Injury definition	Reported as significant risk factors	Outcomes
Hammes et al., 2016	Veteran Football	n = 256 114 injuries number of injured players not stated	Any physical complaint sustained by a player that result from a football match or football training that results in a player being unable to take fully part in future football training and match play	FMS<10 vs FMS = 15-17	HR = 1.9 (1.1-3.1) p<0.05
Duke et al., 2017	Experienced Rugby Union	n = 8 48 injuries (71% players)	Any physical complaint... that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities that resulted in a player being unable to take a full part in future rugby training or match play	FMS ≤14 FMS ≤15	OR = 10.4 (1.3-84.8) p<0.05 Sensitivity = 0.4 (no CI) Specificity = 1.0 (no CI) OR = 3.4 (1.1-10.1) p = 0.03 Sensitivity = 0.4 (no CI) Specificity = 1.0 (no CI) No significant association with asymmetry

**Injury rate stated is a percentage of 90 'player observations' as multiple observations were made for 28 players across two seasons.

Two thirds of studies investigating mixed sports cohorts found no association between the FMS composite score and injury risk (Wiese et al., 2014; Hotta et al., 2015; Warren et al., 2015; Bardenett et al., 2015). The lack of association may be due to each sport having a different rate of injury and different injury risk factors. For example, in the study by Bardenett et al. (2015) the range of disciplines involved included cross-country, American football, soccer, swimming, tennis and volleyball. Each sport has a different injury profile and it may be of little surprise that when pooled, analysis indicated a null result. In a sample of 38 NCAA division 2 female collegiate athletes (soccer, volleyball and basketball) mean FMS scores for non-injured athletes was FMS = 14.7 ± 1.3 compared to 13.9 ± 2.1 for athletes that sustained an injury. Athletes that scored FMS <14 were associated with an increased risk of injury compared to athletes scoring FMS ≥14 (OR = 3.9, 95%CI = 1.0-15.1, p<0.05). In this instance, an association between FMS and injury risk may have been identified as each of the three sports predominate in lower limb-injury, particularly of the knee and ankle (Barber Foss et al., 2014). Despite this a further study conducted in professional basketball screened 34 players within pre-season over the course of four seasons yet failed to establish an association between the FMS composite score and injury (Azzam et al., 2015). This may indicate that factors such as playing level, i.e., professional compared to collegiate, also influence the association between FMS composite score and injury risk.

In rugby union, two studies both found associations between FMS composite score and injury risk (Tee et al., 2016; Duke et al., 2017). Tee and colleagues (2016) used a severe time-loss injury definition of an injury that resulted in greater than or equal to 28 days time-loss from training or match play. By consensus a 28 day time-loss injury is a moderate injury (Fuller et al., 2007a), thus the definition used did not meet the consensus. In a two season study, 62 players were assessed, which produced 90 observations (28 players participated in both seasons but their data was treated as independent) (Tee et al., 2016). Effect sizes indicated moderate differences in FMS scores between injured and non-injured players for both contact (injured 13.1±2.0 vs non-injured 14.3±1.5) and non-contact injuries (injured 13.3±14. vs non-injured 14.3±1.7). Players that scored less than 14 on the FMS were associated with a 6.5 (95%CI = 1.8–23.0) times risk of severe contact injury compared to players who scored 14 or more, while scoring less than 15 on the FMS was associated with a 4.3 (95%CI = 0.9-21.0) times increase in non-contact injury compared with players that scored 15 or more (Tee et al., 2016).

Duke and colleagues (2017) recorded all time-loss injuries that resulted in time-loss from training or match play, and analysis was performed specific to injuries that occurred in the first half and the second half of the season, respectively. This may be due to injury rates having been reported as higher in the early season compared to late season (Roberts et al., 2013), though no rationale is presented for this approach. FMS scores for injured and non-injured players were indifferent (early season: injured 15.0 ± 2.2 vs non-injured 15.6 ± 1.3, late season: injured 15.2 ± 2.3 vs non-injured 15.9 ± 1.2). Players who scored less than 15 on the FMS were associated with 10.4 (95%CI = 1.3 – 84.8) times the risk of injury early season, and 5.0 (95%CI = 1.0-24.2) times the risk of injury in late season, than players who scored 15 or more.

Presently no information is available regarding men's community rugby and the association between FMS composite score and injury risk. The studies involving rugby cited in this review indicated associations between FMS score and injury risk in experienced (Duke et al., 2017) and Professional (Tee et al., 2016) players, but these results may not translate to the community game. Risk of injury in the professional game (the experienced players cohort included international level players) is far greater than that of the community game (Brooks et al., 2005a, b; Roberts et al., 2013). Differences in training load, medical support, and playing intensity between these levels is likely vast. However, the FMS appears to hold potential as a screening tool in rugby and a study involving community players is warranted.

A potential limitation common to the FMS studies detailed in Table 2.4, (excluding Hammes et al., 2016), is the likely difference in exposure of athletes to either training or match-play that was not accounted for during analysis. While the follow-up periods for participants within each study are standardised, i.e., participants were followed for the duration a regular season for the sport they were involved in, individuals' risk of injury likely vary with their exposure to both training and match play. In both rugby and soccer, for example, match-play is associated with higher rates of injury than in training (Williams et al., 2013; McIntosh and Dutfield, 2008b; Hammes et al., 2015; Hägglund et al., 2009; Ekstrand et al., 2010). Having recognised the non-collection of exposure data as a design limitation, only players who gained regular selection for the starting team during the relevant period of competition (selected >60% of matches for which they were available) were included in the FMS study on professional rugby union players (Tee et al., 2016). Likewise, player data were excluded from analysis if the experienced players missed more than 3 games in the first half of the competitive season, or missed three games in the second half of the competitive (Duke et al., 2017). However, large differences in exposure time may still have existed. For example, a player who only plays the final 10 minutes of 61% of games has less chance of receiving a match injury compared with a player who played the full 80 minutes of every game throughout the season. Similarly, if only 4 games are played in each half of the season, players missing 2 games per half season would still be included in analysis despite having only received half the match exposure (i.e., risk). An FMS study investigating injury risk in veteran soccer players demonstrated a more rigorous approach, whereby each player's individual exposure was monitored throughout the study and accounted for during analysis (Hammes et al., 2016). Future research should consider a similar approach to monitoring player exposure, particularly of match-play where injury risk is highest.

2.5 STAGE 3: Develop preventative measures

Stage three of the sequence of injury prevention involves the identification of possible solutions to the injury problem and the delivery of appropriate preventative measures (van Mechelen et al., 1992).

2.5.1 Law changes in rugby

Efforts have been made to reduce the risk of rugby injury globally through a combination of changes to the laws of rugby (the rules that govern the game are referred to as 'laws'), and the stricter enforcement of certain laws by referees. Rugby law changes have been made due to the propensity for injury of certain events during game play. In rugby, tackle events contribute to approximately 50% of all injuries (Garraway and Macleod, 1995), yet tackles to the head or neck (a 'high tackle') of the ball carrier have a higher propensity for injury (RR = 2.2, 95%CI = 1.6-3.6) (Fuller et al., 2010) than tackles below the shoulder. As a result, tackle directives providing clear definitions of a 'high-tackle' were introduced (World Rugby, 2011). Recently, stricter enforcement of the high tackle laws was required from referees (World Rugby, 2016a) to further protect the tackled player from head and neck injuries, and particularly from concussion (Cusimano et al., 2013) which is the most frequent head injury (Roberts et al., 2016).

Another example of law change implemented to reduce global rugby injury risk involves the scrum engagement process. Compared to a non-collapsed scum, collapsed scrums had 4 times the propensity for injury (2.9 (1.5 – 5.4) injuries/1000 events) where the severity of injury was six times greater (22 (12 – 42) weeks time-loss/1000 events) (Roberts et al., 2014). Catastrophic injuries, for example injuries to the spinal cord resulting in permanent disability, have a dramatic impact when they occur. In rugby, approximately 40% of all catastrophic injuries that occurred were related to scrummaging (Quarrie et al., 2002). A new 'crouch, bind, set' scrum engagement process was introduced (Law 20;World Rugby, 2015) which was proposed to improve player safety. This new engagement process reduced the forces associated with the previous 'crouch, touch, pause, engage' engagement process by 20% (Preatoni et al., 2016; Cazzola et al., 2014). This reduction in force is due to the gap between the front row players being reduce so players have less space in which to accelerate before engagement, coupled with the fact that the props must 'pre-bind' on their opponents shirt to encourage greater stability during the engagement process. The effectiveness of this change is under evaluation.

2.5.2 Education in rugby

An alternative approach to improving player safety has been through national education strategies including 'Tackling Rugby Injury' (Chalmers et al., 2004) and 'RugbySmart' (RugbySmart, 2001) in New Zealand, and 'BokSmart' (Viljoen and Patricios, 2012) in South Africa. Tackling Rugby Injury was designed around themes relating to prevention of injury including: coaching, fitness, injury management, tackling and foul play (Chalmers et al., 2004), and was performed as a pilot study to inform the development of, and means of evaluation of a large scale trial (Simpson et al., 1999), later named RugbySmart.

RugbySmart was a joint initiative between the New Zealand Rugby union and the Accident Compensation Corporation (ACC), providers of personal injury insurance cover in New Zealand. In New Zealand, it became compulsory for coaches and referees to complete RugbySmart requirements annually from 2001 in order to continue their rugby coaching or refereeing. Evaluation of the effectiveness of RugbySmart implementation on injury reduction (based on injury claim rates per 100,000 players) indicated 5-year rate reductions in targeted areas including the knee (RR, 90%CI = 0.79, 0.72-0.87), neck/spine (RR, 90%CI = 0.77, 0.62-0.97) and leg (RR, 90%CI = 0.81, 0.68-0.97; excluding knee and ankle) between implementation in 2001 and the evaluation in 2005 (Gianotti et al., 2009).

In South Africa, BokSmart was an initiative between the South African Rugby Union and the Chris Burger/Petro Jackson Players fund (Viljoen and Patricios, 2012) which aimed to prevent catastrophic injuries by providing coaches and referees with evidence-based preventative knowledge and skills (Verhagen and Finch, 2011) at all levels of rugby union in South Africa (Viljoen and Patricios, 2012). A simple pre-participation screen was developed for use by coaches which evaluated a player's medical history in relation to their potential injury risk from rugby participation (Patricios and Collins, 2010). Freely accessible educational resources were provided on a variety of rugby related topics, and a Rugby Medic Programme aimed at training underprivileged rugby-playing communities was run (Viljoen and Patricios, 2012). An evaluation of the effectiveness of BokSmart in reducing catastrophic injury indicated a 40% reduction in Junior catastrophic injury involving the head and neck (IRR = 0.6, 95%CI = 0.5-08), with no difference in Senior players (IRR = 1.2 (0.7-2.0) (Brown, 2014).

To inform future development and dissemination plans for BokSmart, injury prevention behaviours of coaches were assessed from 3921 player questionnaires (junior = 279, senior = 1642) following BokSmart's coach-directed education (Brown et al., 2016). Data pertaining to 16 behaviours were collected using Knowledge, Attitude and Behaviour questionnaires, where analysis indicated 75% of coach behaviours were associated with receiving information on that topic. However, results also highlighted that referees and Physiotherapists could also be targeted with safety information, and that information for players should be made age specific.

2.5.3 Exercise training in team sports

Sports injuries are the result of the body's tissue being exposed to a force beyond its tolerance, either as an acute excessive load or following repetitive exposure to submaximal loads that result in injury (McIntosh, 2005). Exercise training strategies may positively influence a player's posture and kinematics, thus reducing injurious loading patterns and facilitating the body's ability to withstand the external load. Movement control exercises have been proposed as an approach to reduce sports injury by improving the kinematics of the musculoskeletal system via neuromuscular training (McIntosh, 2005; Myer et al., 2006). Movement control exercises target improvements of balance, proprioception and coordination, eccentric strength and cutting and landing technique. No randomised controlled trial has reported these types of exercise as a preventive measure in rugby despite a number of trials from sports including soccer (Soderman et al., 2000; Heidt et al., 2000; Soligard et al., 2008; Gilchrist et al., 2008 Emery and Meeuwisse, 2010; Holmich et al., 2010; LaBella et al., 2011), basketball (Eils et al., 2010; LaBella et al., 2011; Longo et al., 2012), handball (Wedderkopp et al., 1999; Andersson et al., 2016), floorball (Pasanen et al., 2008), and Australian rules football (Finch et al., 2015; Hides and Stanton, 2014; Gabbe et al., 2006).

The results of randomised controlled trials (RCTs) that implemented exercise training programmes for injury prevention are detailed in Table 2.5 and Table 2.6. These studies have been divided into programmes needing specialised equipment, including; wobble/balance boards, mini-trampolines, medicine balls, Swiss balls and exercise bands (Table 2.5), and programmes with no equipment requirements (Table 2.6). In these studies, the main focus is on prevention of lower limb injuries as this is the predominant injury location across the sports, with just one paper that investigated overuse shoulder injuries (Andersson et al., 2016).

Table 2.5. Summary of injury prevention randomised controlled trials where injury prevention interventions required participants to use equipment to complete the exercises.

Authors	Intervention elements	Population	Sample size	Injury focus	Outcome (95% CI)
Wedderkopp et al., 1999	Multi modal including ankle disc	Youth female handball	n = 37	Lower-limb	OR = 0.2 (0.1-0.3)
Soderman et al., 2000	Wobble board	Women's soccer	n = 21	Lower-limb:	
				Practice	RR = .2 (0.7-2.1)
				Game	RR = 1.2 (0.5-3.4)
				Minor	RR = .0 (0.5-2.2)
				Moderate	RR = 0.78 (0.3-1.9)
				Major	RR = 1.0 (2.1-57.3)
Emery et al., 2005	Multi modal including wobble board	Healthy youth	n = 27	Overall	RR = 0.2 (0.1 - 0.9)
Olsen et al., 2005	Multi modal	Youth sports	n = 1837	Lower limb	RR = 0.5 (0.4-0.8)
McGuine and Keene, 2006	Wobble board	High school athletes (mixed sex)	n = 765	Ankle sprains	RR = 0.6 (0.4-1.0)

Table 2.5 (*continued*) Summary of injury prevention randomised controlled trials where injury prevention interventions required participants to use equipment to complete the exercises.

Authors	**Intervention elements**	**Population**	**Sample size**	**Injury focus**	**Outcome (95% CI)**
Pasanen et al., 2008	Multi including medicine ball and wobble board	Female Floorball	n = 457	Lower-limb: Acute (all) Non-contact	RR = 0.7 (0.5-0.9) RR = .3 (0.2-0.6)
Emery and Meeuwisse, 2010	Multi including wobble board	Youth soccer (mixed sex)	n = 744	Overall Acute onset Lower-limb Ankle sprain Knee sprain	RR = 0.6 (0.4–1.0) RR = .6 (0.4-0.9) RR = 0.9 (0.4-1.1) RR = .5 (0.2-1.0) RR = 0.4 (0.1-1.8)
Hides and Stanton, 2014	Multimodal including pilates and ultrasound feedback	Men's Australian Rules Football	n = 46	Lower-limb injury	OR = 0.1 (0.02-0.7)*
Finch et al., 2015	PAFIX (multi modal using mini-trampoline	Men's Australian Rules Football	n = 1564	Overall Lower-limb Knee	RR = .9 (0.7-1.2) RR = 0.8 (0.6-1.1) RR = .5 (0.2-1.1)
Andersson et al., 2016	Multimodal – using medicine ball and ankle disc	Elite handball (mixed sex)	n = 667	Overuse shoulder	OR = 0.8 (0.5-1.0)

**refers to motor control training occurring before time point 3 where intervention n = 32 and control n = 14.*

Table 2.6 Summary of injury prevention randomised controlled trials using exercise based interventions to reduce injury outcomes.

Authors	Intervention elements	Population	Sample size	Injury focus	Outcome (95% CI)
Pope et al., 1998	Stretching	Army recruits	n = 1093	Below knee	HR = 0.9 (0.5-1.6)
Heidt et al., 2000	Proprioception	Youth female soccer	n = 300	Lower-limb	OR = 0.4 (0.2-1.0)
Pope et al., 2000	Stretching	Army recruits	n = 1538	All lower-limb	HR = 1.0 (0.8-1.2)
				Soft-tissue	HR = .8 (0.6-1.1)
				Bony injury	HR = 1.2 (0.9-1.8)
Gabbe et al., 2006	Eccentric strength	Men's Australian rules football	n = 334	Hamstring injury	RR = .2 (0.5-2.8)
Emery et al., 2007	Proprioception	High school basketball (mixed sex)	n = 920	Any acute	RR = .8 (0.6-1.1)
				Acute onset	RR = 0.7 (0.5-1.0)
				Lower-limb	RR = .8 (0.6-1.2)
				Ankle sprain	RR = 0.7 (0.5-1.1)
Soligard et al., 2008	FIFA 11+	Youth female soccer	n = 892	Lower-limb:	
				Overall injury	RR = 0.7 (0.5-1.0)
				Overuse injury	RR = .5 (0.3-0.8)
				Severe Injury	RR = 0.6 (0.4-0.8)
Gilchrist et al., 2008	Santa Monica Prevent injury & enhance performance (PEP)	Collegiate female soccer	n = 1435	Knee:	
				Overall knee	RR = 1.0 (0.7-1.6)
				ACL	RR = .6 (0.2-1.4)
				Non-contact ACL	RR = 0.3 (0.1-1.4)
Brushoj et al., 2008	Multi modal	Adult army recruits	n = 1020	Overall knee	RR = .1 (1.0-1.1)
				Overuse knee	RR = 1.1 (1.0-1.1)

Table 2.6 (*continued*) Summary of injury prevention randomised controlled trials using exercise based interventions to reduce injury outcomes.

Authors	**Intervention elements**	**Population**	**Sample size**	**Injury focus**	**Outcome (95% CI)**
Steffen et al., 2008	FIFA 11	Youth female soccer	N = 2092	Overall injury	RR = 1.0 (0.8-1.2)
Eils et al., 2010	Proprioception	Basketball	n = 232	Ankle	OR = 0.36 (0.2-0.8)
Holmich et al., 2010	Multi	Soccer	n = 1211	Groin (adductor related)	HR = 0.7 (0.4-1.2)
Jamtvedt et al., 2010	Static stretching	Physically active adults	n = 2377	Overall injury Muscle, tendon or ligament	HR = 1.0 (0.8-1.1) HR = .8 (0.6-1.0)
Coppack et al., 2011	Strength & stretching	UK army recruits	n = 1502	Overuse anterior knee pain	HR = .3 (0.1-0.5)
LaBella et al., 2011	Multi	Female soccer & basketball athletes	n = 1558	Lower-limb: Acute NC ankle sprains NC knee sprains NC ACL	RR = 0.3 (0.2-1.0) RR = .3 (0.2-0.9) RR = 0.3 (0.1-0.9) RR = .2 (0.0-1.0)
Petersen et al., 2011	Strength	Men's soccer	n = 942	Acute hamstring New hamstring	RR = .3 (0.2-0.6) RR = 0.4 (0.2-0.5)
Walden et al., 2012	Strength	Youth female soccer	n = 4564	Acute knee: Overall ACL Complaint ACL Overall knee	RR = 0.4 (0.2-0.9) RR = .2 (0.1-0.6) RR = 0.5 (0.3-0.9)

Table 2.6 (*continued*) Summary of injury prevention randomised controlled trials using exercise based interventions to reduce injury outcomes.

Authors	**Intervention elements**	**Population**	**Sample size**	**Injury focus**	**Outcome (95% CI)**
Longo et al., 2012	FIFA 11+	Men's basketball	n = 1211	Overall Lower-limb	OR = 0.3 (0.2-0.6) OR = .4 (0.2-0.8)
van Beijsterveldt et al., 2012	FIFA 11	Amateur men's soccer	n = 456	Overall	RR = 1.0 (0.8-1.2)
Steffen et al., 2013	FIFA 11+	Youth female soccer	n = 26	Overall, Lower-limb	RR = 0.3 (0.1-0.8) RR = .3 (0.1-1.0)
Grooms et al., 2013	FIFA 11+	Collegiate male soccer	n = 41	Lower-limb Burden	RR = 0.3 (0.1-0.9) RR = .2 (0.1-0.5)*
Owoeye et al., 2014	FIFA 11+	Youth male soccer	n = 414	Overall Lower-limb Match	RR = 0.6 (0.4-0.9) RR = .5 (0.3-0.8) RR = 0.4 (0.2-0.6)
Hammes et al., 2015	FIFA 11+	Veteran men’s soccer	n = 265	Overall	RR = 0.9 (0.6-1.5)
Silvers-Granelli et al., 2015	FIFA 11+	Collegiate male soccer	n = 1525	Overall Training Game	RR = 0.5 (0.5-0.6)* RR = 0.5 (0.4-0.6) RR = .6 (0.5 -0.7)*

*Indicates where outcomes were calculated using data presented in the article.

Over half of all injury prevention RCTs were based in soccer (17/31 trials). Soccer has the world's largest playing population (reported at 265 million Worldwide: Kunz, 2007) and thus the greatest potential of all sports for impact on health, social and economic injury burden. While the theory that movement control exercise interventions may reduce injury, in practice, the efficacy of interventions has varied. Of studies that required the use of equipment (Table 2.5), two (20%) of ten studies (Soderman et al., 2000; Finch et al., 2015) demonstrated no clear reduction of match lower-limb injury (game RR, 95%CI = .2, 0.5-3.4), though Finch et al. (2015) did demonstrate reduced risk of anterior cruciate ligament injury (RR, 95%CI = 0.5, 0.2-1.1). Poor compliance with a home-based balance training programme was suggested as a factor effecting intervention success in women's soccer (Soderman et al., 2000), despite the research team having contacted players directly to maintain motivation. In contrast to this, a home-based balance training programme in youth athletes (participating in soccer, volleyball, basketball and hockey) was demonstrated to be efficacious (overall injury RR, 95%CI = 0.2, 0.1-0.9) (Emery et al., 2005). While intervention compliance wasn't commented on in this study, it's possible that youth athletes were more accepting of the programme and compliance was probably higher compared to adults (Soderman et al., 2000), and as a result and the programme was demonstrated as efficacious in reducing injury. Eight (80%) of the ten studies requiring equipment did demonstrate efficacy in reducing injury. The common theme across these studies was the focus on balance and proprioception (excluding Andersson et al. (2016), where the focus was on upper-body range, mobility and strength, and Hides and Stanton (2014) where the focus was on voluntary muscle contraction of deep abdominals and multifidus) suggesting that balance and proprioception exercises should be considered in injury prevention programmes where lower-limb injury is dominant.

Twenty-three intervention trials (Table 2.6) had no requirement for specialist equipment. Eight (35%) of the twenty-five trials demonstrated unclear effects on overall injury rates (Pope et al., 1998; Pope et al., 2000; Gilchrist et al., 2008; Brushoj et al., 2008; Holmich et al., 2010; Jamtvedt et al., 2010; van Beijsterveldt et al., 2012; Hammes et al., 2015). Of these eight studies five studies included static stretching of lower-limb muscles such as the hamstrings, quadriceps and calf muscles (Pope et al., 1998; Pope et al., 2000; Gilchrist et al., 2008; Brushoj et al., 2008; Jamtvedt et al., 2010). A meta-analysis considering static stretching interventions concluded that routine static stretching does not reduce overall lower-limb injuries but may reduce musculotendinous injuries (Small et al., 2008). Static stretching exercise is not efficacious to include in an injury prevention programme unless a reduction in tendon injuries is a primary outcome, such as demonstrated in handball, where overuse injuries effecting the shoulder tendons were a primary concern (Andersson et al., 2016).

Efficacy of the FIFA 11+ has been demonstrated across a range of participants involving different sports. The FIFA 11+ does not require specialist equipment, and uses a range of balance, proprioceptive and coordination exercises, combined with eccentric and plyometric strength, with a focus on movement quality during landing and cutting tasks (Soligard et al., 2008). Trials have demonstrated the FIFA 11+ as efficacious for lower-limb injury prevention in youth female (Steffen et al., 2013; Soligard et al., 2008), youth male (Owoeye et al., 2014) and collegiate male (Silvers-Granelli et al., 2015) soccer players and men's basketball players (Longo et al., 2012). Of the two studies that were unable to demonstrate a reduction in injury rates following FIFA 11+ implementation (Hammes et al., 2015; van Beijsterveldt et al., 2012), neither reported harm following implementation. On the balance of this evidence, practice of the FIFA11+ programme should be recommended to all soccer players, and similar exercises may be beneficial for reducing lower-limb injury in other sports, including rugby.

Considering the components of the FIFA 11+ programme, proprioceptive and plyometric exercises improve players' ability to manage external loads due to enhanced proprioceptive feedback mechanisms (Lloyd, 2001). Evidence demonstrates that eccentric hamstring training, such as the practice of the Nordic hamstring exercise can reduce the incidence of hamstring injuries (Arnason et al., 2008; Brooks et al., 2006; Gabbe et al., 2006; Seagrave et al., 2014). Eccentric hamstring strength was found to be a protective exercise against hamstring injury in professional rugby players (Brooks et al., 2006) where players that performed eccentric hamstring exercises (IIR, 95%CI = 0.39, 0.25-0.54) demonstrated reduced overall (match and training) hamstring injury rate compared to players who performed their regular strengthening programmes (IIR, 95%CI = 1.1, 0.74-1.4). Coaches' feedback to players regarding performance of cutting and landing tasks may facilitate players to correct poor movement patterns thus reducing harmful external loads associated injury risk. Feedback provided with the intention of correcting torso posture, torso movement and foot placement relative to the body's centre of mass may reduce risk of injury by reducing valgus knee loading such as during cutting and landing tasks (Dempsey et al., 2007; Dempsey et al., 2009; Dempsey et al., 2014).

With respect to shoulder injury prevention, overuse injuries were reduced (OR, 95%CI = 0.8, 0.5-1.0) following a programme of external strength training, thoracic and glenohumoral joint mobility exercises (Andersson et al., 2016). The aetiology of rugby shoulder injuries is not of overuse but predominantly blunt force trauma (Headey et al., 2007). As part of BokSmart a guide was produced for preventive rehabilitation of the shoulder (Gray, 2009). The BokSmart guide details a progressive programme of exercises including scapular control, glenohumoral joint control, concentric and plyometric strengthening exercises. The modes of exercise included reflect those evidenced for lower-limb injury prevention, however no evidence regarding the efficacy of the programme has been published. While some exercises from the programme including push-ups, windmill, scapula protraction and retraction, and step walking could be incorporated into a programme for men's community rugby, the majority exercises require provision of fitness equipment, and with a recommended application of exercises up to 3 times a day 5 times per week, the programme would may require substantial revision to suit the context of a community rugby club, who commonly train just twice weekly.

Fifteen per cent of all rugby injuries are to the head and neck (Roberts et al., 2013) where concussion is the predominant diagnosis (Roberts et al., 2016). Incidence of concussion in rugby has been reported at a rate of 1.5/1000 hours (Roberts et al., 2016). Concussion is the most common time-loss related head injury and accounts for up to 12% of all pitch attendances for head based injury (Roberts et al., 2014). Limited research exists on methods that may prevent concussive events, while across sports the two main approaches used to prevent head injuries include using a helmet and rule modifications (Steffen et al., 2010). Studies have investigated isometric neck strength in relation to head accelerations in sports athletes and professional rugby players (Eckner et al., 2014 Dempsey et al., 2015). Greater isometric neck strength transferred into lesser head accelerations when tested with a loading apparatus (Eckner et al., 2014) and during a simulated ruck condition (Dempsey et al., 2015). Both studies suggested that decreasing the acceleration of the head maybe an important component in reducing the incidence of concussion. Importantly, a basic programme of isometric neck strength training has been shown to significantly increase isometric neck strength in professional rugby players after just 5 weeks of training (Geary et al., 2014), and that a significant decrease in the number of cervical spine injuries was seen in elite players using an isometric neck strengthening programme (Naish et al., 2013). No evidence is currently available regarding neck strength and associated injury incidence in the community game. However, given that community players aren't as highly conditioned as elite players, community players have a greater potential for resistance training to increase cervical spine muscle strength and to reduce subsequent risk of cervical spine injury or concussion. To further evidence supporting isometric neck strength training as a preventative measure for head and neck in community players, a prevention programme incorporating isometric neck strength training needs to be implemented in community rugby where the incidence of concussion and cervical spine injury is also measured.

2.5.4 Injury prevention via movement control exercise in men's community sport

Relatively little sports injury prevention research using movement control exercise programmes has been published specific to the context of community sports environments. From Table 2.5 and Table 2.6 only four studies (Finch et al., 2015; Gabbe et al., 2006; Petersen et al., 2011; Hammes et al., 2015) considered community players (exceptions noted that both professional and amateur players participating in the study by Petersen et al. (2011) and Hammes et al. (2015) only included veteran players). Of these studies, the only research group to detail the many processes involved before conducting a randomised controlled trial is that of Finch and colleagues, which justifies specific attention due to the focus of this thesis.

The Preventing Australian Football Injuries with Exercise (PAFIX) (Finch et al., 2009) protocol was published and then integrated as part of the National Guidance for Australian football Partnerships and Safety (NoGAPS) Project (Finch et al., 2011). The development of the PAFIX programme was a 4 year process, spanning 2006 to 2009 (Finch et al., 2009), where the efficacy of the programme for lower-limb injury reduction was published in 2015 (Finch et al., 2015; Table 2.5). This research aligns with stages 1 to 4 of TRIPP (Finch, 2006). Elements from NoGAPS project also target the implementation and dissemination strategies necessary for the efficacious programme to become an effective programme (stages 5 and 6 of TRIPP: Finch, 2006). The processes involved to achieve this are described through a series of publications (Finch et al., 2010; Finch et al., 2011; Finch et al., 2014), with the process having taken over 10 years, and is ongoing. The rationale for the studies to prevent injury in Australian rules football in Australia, closely reflects the justification for injury prevention in rugby in England as detailed in Table 2.7.

Table 2.7 Comparison of the rationale that justifies the need for injury prevention in Australian rules football in Australia and Rugby in England (adapted from Finch et al., 2011)

Australian rules football	Rugby
• is the second most popular participation sport in Australian men (Swan et al., 2009)	• is the second most popular team ball sport in the UK (Sport England, 2016)
• has large numbers of both formal and informal community participants, including women and indigenous groups (Australian Bureau of Statistics, 2007)	• has large numbers of both formal and informal community participants (World Rugby, 2016b)
• is delivered through strong networks of local clubs within regional leagues with common administration	• is delivered through strong networks of local clubs within regional leagues with common administration (RFU, 2017)
• is arguably the best resourced and institutionalised sport in Australia in terms of administrative, governance and management networks	• is a well resourced and institutionalised sport in England in terms of administrative, governance and management networks
• has a high media and public profile	• has a high media and public profile
• has structured training programmes provided by clubs and coaches	• has structured training programmes provided by clubs and coaches
• has a strong focus on group participation and team building;	• has a strong focus on group participation and team building
• is a relatively high-risk community sport for lower-limb injury (Gabbe and Finch, 2001)	• is a relatively high-risk community sport for lower-limb injury (Roberts et al., 2013)

For the development and evaluation of an efficacious exercise intervention programme, 3 phases were outlined (Finch et al., 2011). Phase 1 included the translation of available scientific evidence for injury prevention into formal, practical exercise training guidelines for dissemination to community clubs. A mixed methods approach was used whereby quantitative evidence was gathered from published research, and qualitative evidence was developed through discussion with stakeholders and consultation with a wider group of experts (Finch et al., 2011). Phase two was the refinement of the intervention by obtaining feedback on the programme content and format. Phase two facilitated development of guidelines to improve the understanding and likelihood of implementation, alongside informing any further materials that were considered necessary by the end-users (Finch et al., 2011). Phase 3 was then the conduction of a randomised controlled trial to assess the efficacy of the intervention and to gain further insight into enablers and barriers to programme implementation before nationwide dissemination and evaluation of the programme's effectiveness. This process provides a method that could be applied during the development of an injury prevention exercise programme for men's community rugby in England.

2.6 Chapter summary

The process of preventing injury in men's community rugby should be guided by the stages proposed in the Translating Research into Injury Prevention Practice model (Finch, 2006). Injury surveillance has identified the burden of injury in men's community rugby, and that this burden is relatively high, warranting means of reduction. Further research into the risk factors for injury, particularly intrinsic risk factors that may be modifiable through intervention means seems justified. Pre-season screening using the Functional Movement Screen appears to be a method of identifying rugby players that may be at increased risk of injury, guiding practitioner intervention. Further research using the FMS is warranted for men's community rugby where a robust statistical approach should be applied. Specifically, the statistical approach used should account for players' individual match exposure, as this has rarely been done in practice. Reflecting on research into injury prevention in other sports, it is clear that movement control exercises performed regularly during a warm-up can be very beneficial in reducing lower-limb injuries. Such an approach would greatly benefit men’s community rugby, though with a very different injury profile to sports such as soccer and basketball, a new programme is warranted that reflects the injury profile of rugby. An informed approach during the design of any such programme must account for the context specific nature of community men’s rugby in order to maximise compliance, thus maximise the potential success of any such programme. It is clear that before a large scale trial of a new exercise intervention is conducted, a feasibility study is warranted to inform the specific implementation context of men’s community rugby.

CHAPTER THREE

ASSOCIATION OF THE FUNCTIONAL MOVEMENT SCREEN WITH INJURY OUTCOME IN MEN'S COMMUNITY RUGBY

3.1 Introduction

In men's community rugby, one player gets injured every three team games (Roberts et al., 2013). On average the severity of these injuries requires five weeks out of competition in order to resolve (Roberts et al., 2013). However, injury risk factors in rugby are poorly understood with the exception of previous injury, which has consistently been identified as a risk factor for further injury (Quarrie et al., 2001; Chalmers et al., 2012). It is important to identify risk factors, in particular modifiable risk factors, to inform injury reduction strategies.

One approach to understanding a player's injury risk is to conduct screening, but screening often requires expertise of a skilled practitioner due to the complexity of the different screens (Brukner and Khan, 2012). A simple and quick-to-perform injury risk assessment would be of great benefit to community teams. The Functional Movement Screen™ (FMS) is economical to administer requiring little practitioner time and where the cost of equipment is not prohibitive (Cook et al., 2006a, b). The FMS consists of seven movement patterns that assess individuals' strength, balance and range of motion (Cook et al., 2006a, b). The primary function of the FMS is to identify areas of movement deficiency in individuals, but it has also been used to assess injury risk in a range of athletic populations, though with conflicting results. The FMS was not associated with injury risk in runners (Hotta et al., 2015), high school mixed sports athletes (including cross-country, football, soccer, swimming, tennis and volleyball) (Bardenett et al., 2015), division 1 mixed sports athletes (including basketball, football, volleyball, track and Field, swimming, soccer, golf and tennis) (Warren et al., 2015) or professional soccer players (Zalai et al., 2015). However, associations with injury risk have been identified in collision based sports including American football (Kiesel et al., 2007; Kiesel et al., 2014) and rugby union (Tee et al., 2016; Duke et al., 2017). In American football, movement competency (Kiesel et al., 2007) and presence of left to right asymmetry (Kiesel et al., 2014) were associated with increased risk of injury. In contrast to these results, in rugby union movement competency

(Tee et al., 2016; Duke et al., 2017) and individual movement pattern scores (Tee et al., 2016) were associated with increased risk of injury, but asymmetry and risk of injury were not associated (Duke et al., 2017). However, none of these studies accounted for players' match exposure which is associated with risk of injury in rugby (Williams et al., 2017). In fact, only two studies have accounted for players' match exposure during analysis (Hammes et al., 2016; Chalmers et al., 2017). In veteran football players, Hammes et al. (2016) reported no clear association between in FMS score and playing time until first injury. In junior Australian football players, Chalmers et al. (2017) also reported no association between FMS score and injury. However, the presence of one or more asymmetries was associated with a very likely harmful 1.9 times increase in risk of injury, escalating to a most likely harmful 2.8 times risk of injury where players had 2 or more asymmetries (Chalmers et al., 2017). As such asymmetry should be considered during future analysis of the association between FMS performance and injury.

This study will investigate the association between FMS performance (including the influence of movement asymmetry and pain), individual player match exposure and time-loss injuries, and whether a cut-off score for the FMS can be established for a men's community rugby population.

It was hypothesised that players with a FMS score <14 would have a higher injury rate than players with an FMS score of 14 and above. It was also hypothesised that players that displayed either pain, or asymmetry on FMS testing would have a higher injury rate than players that did not have pain or demonstrate movement asymmetry.

3.2 Method

3.2.1 Participants

The playing population from which the study sample was recruited has previously been described as Semi-professional (Rugby Football Union (RFU) levels 3-4; highest level of English community rugby), Amateur (RFU levels 5-6) and Recreational (RFU levels 7-9) (Roberts et al., 2013). An inclusion criteria was that participating clubs had to have 'medical practitioner' that held a recognised qualification limited to sports therapist, osteopath, chiropractor, physiotherapist, or doctor to diagnose and record injuries. At the time of recruitment, participants were injury free (self-reported) and all were considered by the coaching team to be eligible and under consideration to play in the club's 1st team for the forthcoming season.

3.2.2 Ethical approval and consent

Participating clubs were provided with study information and full instructions for testing procedures prior to the testing session taking place which was then disseminated to all players who provided written informed consent at the start of the testing session. Ethics approval was granted by the University of Bath, Research Ethics Approval Committee for Health.

3.2.3 Examiners

Fourteen people acted as raters during the testing period, attending participating clubs in groups of 4. All raters had a sports science background and included undergraduate students, post graduate students, academic post-doctoral and senior lecturing staff. Raters with similar and varying backgrounds have previously been shown to have excellent intra-rater (interclass correlation coefficient (ICC), 95% confidence interval (CI), = 0.81, 0.69-0.92) and inter-rater reliability (ICC, 95% CI, = .81, 0.70-0.92) when delivering the FMS (Bonazza et al., 2017).

3.2.4 Procedures

FMS data were collected during pre-season (between July15th and August 21st 2013) at each club. After an introduction to the testing procedures by the research team leader, participants signed informed consent forms. Participants self-reported primary playing position and age (years) and the research team recorded height (m) (Leicester Height Measure, Seca, UK) and mass (kg) (SC-240 body composition monitor, Tanita, USA). Participants were then assessed using the FMS in an indoor area within the club.

3.2.5 Functional Movement Screen™

Participants wore shorts, T-shirts, their normal trainers and were divided into four groups of similar size with one researcher screening each group. Participants were not allowed to complete a warm-up or to perform preparatory stretching prior to testing. The FMS was conducted using the standard method (Cook et al., 2006a, b). For each FMS component a central demonstration with standard verbal instructions was provided by the research team lead to ensure that all participants received the same information prior to screening. Each component was repeated three times by participants. Component movement scores were recorded in real-time by the raters who were able to change their viewing position. FMS components were scored on an ordinal scale (0-3) and the total composite score was calculated according to standardised criteria (Cook et al., 2006a, b). For unilateral movement patterns (inline lunge, rotational stability, shoulder mobility, active straight leg raise and hurdle step) scores were recorded for right and left sides. Asymmetry was calculated by a difference of 1 or more points being scored for the movement quality / performance from the left compared to the right side of the body. Where a difference in score was recorded for a unilateral movement pattern, the lower score for was used when the composite score was calculated.

3.2.6 Match exposure

For every 1st team match of the 2013-14 rugby season, participating clubs recorded individual player match exposure using a standardised form. Match exposure was recorded as 20, 40, 60 or 80 minutes for a player having played 0-20, 21-40+, 41-60 or 61-80+ minutes (Fuller et al., 2007a), respectively.

3.2.7 Player injury

The medical practitioners at participating clubs completed and returned standardised injury forms. Any injury incurred during a first team match resulting in an absence from participation in match play for 8 days or more from the day of the injury was defined as a "time-loss" injury (Fuller et al., 2007a). The date on which the injured player was fit for game selection (whether or not they actually played on that date) was recorded as the return to play date. Injury severity was calculated as the difference between the date of injury and the 'return to play' date, recorded as the number of days missed. For all time-loss injuries, information requested detailed the anatomical site, injury type, injury event, treatment, and time of injury. Injury diagnoses were recorded using the Orchard Sports Injury Classification System version 8 (Rae et al., 2005) by the injury management staff. Only injuries incurred during match play were recorded and therefore absences from match play due to illness or injuries incurred through any other activity (including rugby training) were excluded.

3.2.8 Statistical Analysis

Data analysis was performed using SPSS (Version 22 for Windows, Armonk, NY. IMB Corp). Descriptive characteristics for player demographics were reported as mean ±

standard deviation (SD). Mean composite FMS scores were compared according to players' injury status (injured / non-injured).

Injury incidence rates (IIRs) were reported per 1000 player match-hours and severity recorded as the number of days absence from 1st XV match play. Injury burden was reported as total time-lost (days) per 1000 player match-hours. The sum of injuries and sum of exposure was used to calculate incidence of overall (≥8 days time-loss) and severe injuries (>28 days time-loss). Effect sizes (ES) were quantified and considered as trivial (≤0.2), small (>0.2-0.6), moderate (>0.6- 1.2), large (>1.2-2.0) and very large (>2.0-4.0) (Batterham and Hopkins, 2006). A General Estimating Equation (GEE) was used to determine associations between FMS score, asymmetry, pain and injury count. As the data was zero-inflated, the Pearson chi-squared adjustment was applied to account for over-dispersion (Stokes et al., 2012). Regression analysis was offset for exposure (hours) and was adjusted for club (cluster), playing level stratification and player (random effects). Analysis was performed for any injury (≥8 days time-loss), severe injury (>28 days time-loss) and injury-burden (time-lost days). Results are presented as rate ratio (RR) with 90% confidence intervals (90%CI) and interpreted using clinical-magnitude based inference (Hopkins and Batterham, 2016). Threshold values for unlikely/harmful (25) and most/very unlikely (0.5) were used to derive the odds ratio for making mechanical inference.

3.3 Results

3.3.1 Descriptive summary

In total, 23 clubs (men's 1st team only) were recruited (Figure 3.1), from which 433 players (age = 24.9 ± 4.5 years, height = 181 ± 7 cm, mass = 4.4 ± 13.0 kg, body mass index = 28.9 ± 3.6 kg/m^2) volunteered to participate. The median FMS score for all 433 players was 14 (mean ± standard deviation (SD) = 14.1 ± 2.5). Overall 24% of players reported pain and 72% of players displayed asymmetry on ≥1 of the FMS movement patterns. Asymmetry (42% of players) and pain (15% of players) were most commonly reported for the shoulder mobility movement pattern.

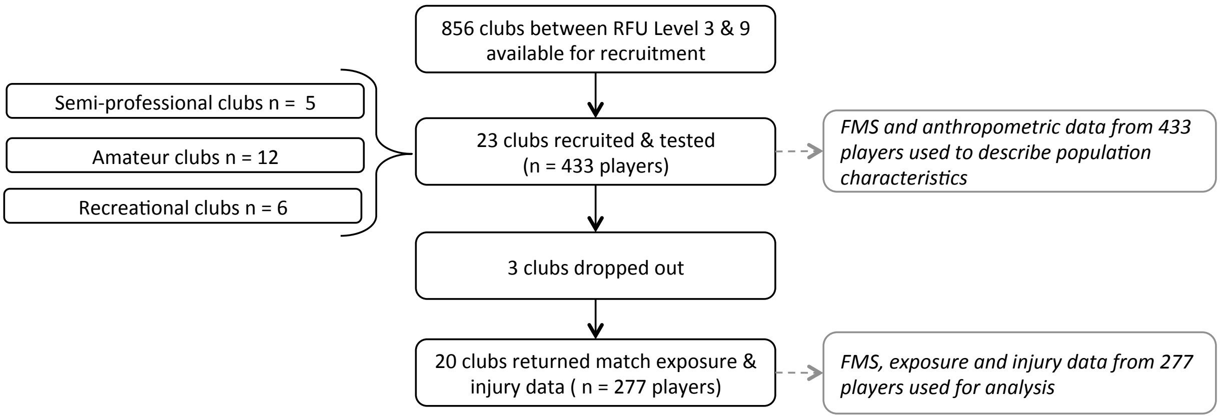

Figure 3.1 Overview of the reach of the study, including the number of clubs that participated, dropped out, and how data was filtered for analysis.

3.3.2 Injury and FMS overview

Due to factors including club withdrawal from the study and individual players either leaving a club or not playing for the 1st team, time-loss injury and individual match exposure data was reported for 277 (64%) players. The distribution of FMS scores for these 277 players, stratified by injury status is displayed in Figure 3.2. Of 277 players, 57 (21%) players accumulated 74 injuries across all 4359 player match-hours (equivalent to 109 matches). Overall injury incidence (≥8days time-loss) was 17.0 (90%CI = 14.0–20.6) injuries/1000 player match-hours. Of the 57 injured players, 30 players accumulated 35 severe (>28 days time-loss) injuries with an incidence of 8.0 (90%CI = 6.1–10.6)/1000 player match-hours. The injury burden was 655 (90%CI = 634-675) days /1000 player match-hours. Contact (n = 57) and non-contact injuries (n = 9) accounted for 77% and 12% of injuries, respectively, while no event was reported for 8 (11%) injuries. Difference in mean FMS score between players with any injury (14.0 ± 2.7) and non-injured players (14.1 ± 2.6) was trivial (ES, 90% CI = 0.04, -0.19 – 0.27; Figure 3.2). The difference in mean FMS score between players who sustained a severe injury (13.5 ± 2.6) and non-injured players (14.1 ± 2.6) was also trivial (ES, 90% CI = -0.22, -0.53 – 0.09; Figure 3.2).

Figure 3.2. Mean and 90% confidence limits for FMS scores stratified by injury definition; no injury, any injury (≥8 days), and severe injury (>28 days). Horizontal error bars represent frequency of FMS scores.

3.3.3 Association of FMS score with injury

The association of FMS score and injury incidence was trivial for overall injury (RR, 90%CI = 0.96, 0.88–1.04) and severe injury (RR, 90%CI = 0.92, 0.83–1.02) (Figure 3.4). A 1-unit increase in FMS score was associated with a possibly beneficial 10% lower injury burden (RR, 90%CI = 0.90, 0.82-0.98).

3.3.4 Determination of a FMS 'cut-off' score

Rate ratio analyses determined associations between FMS cut off scores and injury outcome at each FMS cut off score between 13 and 17 (Figure 3.3). Players that scored ≥16 compared to players that scored <16 on the FMS were associated with a very likely beneficial 60% lower injury burden (RR, 90%CI = 0.4, 0.2-0.8), a likely beneficial 50% lower severe injury incidence (RR, 90%CI = 0.5, 0.2-1.0) and a likely beneficial 30% lower overall injury incidence (RR, 90%CI = 0.7, 0.5-1.1).

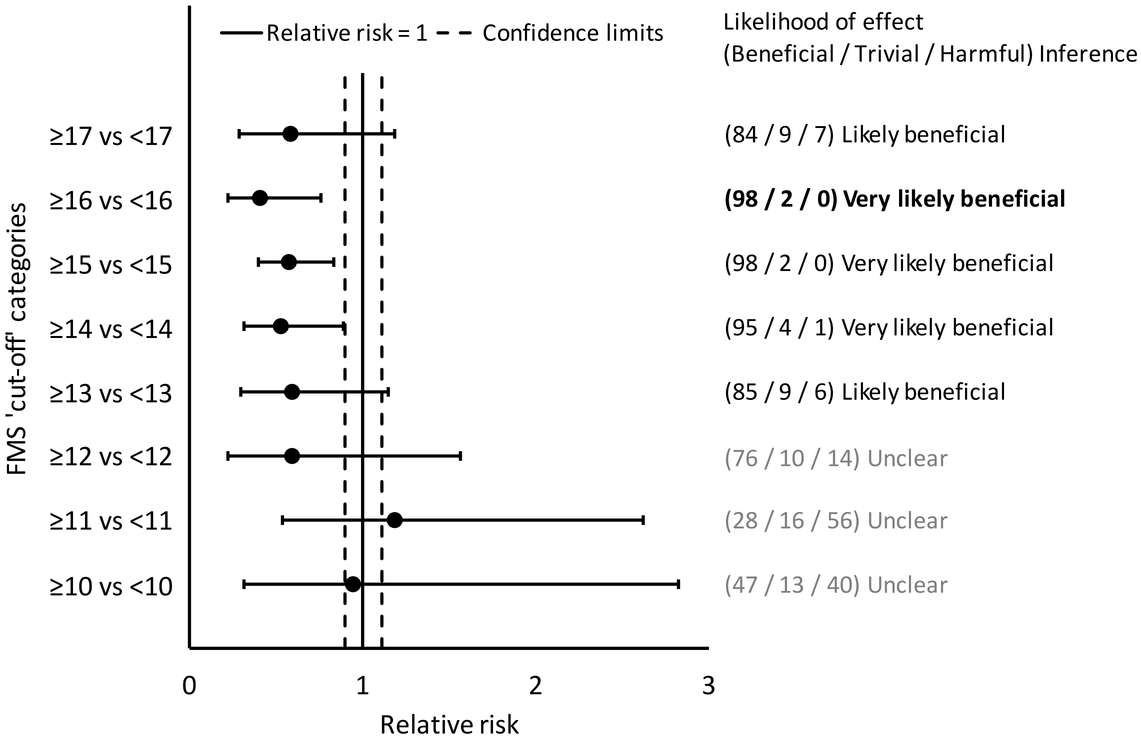

Figure 3.3. Forest plot comparing injury burden (days/1000 player match-hours) by FMS cut-off scores. The right side of the figure displays the likelihood of effect. The largest effects are highlighted in bold.

3.3.5 Association of pain and asymmetry with injury

Univariate analysis indicated players displaying 1 or more asymmetries were associated with a very likely harmful 2.5 times higher severe injury incidence (RR, 90%CI = 2.5, 1.0–6.2) and very likely harmful 2.4 times higher injury burden (RR, 90%CI = 2.4, 1.4–4.3; Figure 3.4) compared to players with no asymmetry. Players who reported pain on 1 or more FMS components were associated with a likely harmful 1.8 times higher injury burden (RR, 90%CI = 1.8, 1.0–3.2) compared to players who did not report pain. When asymmetry was considered as a count variable, each additional asymmetry players displayed was associated with a likely harmful 40% higher severe injury incidence (RR, 90%CI = 1.4, 1.0–2.0) and injury burden (RR, 90%CI = 1.4, 1.1–1.8). There was no clear association between count of painful movement patterns with either severe injury incidence (RR, 90%CI = .8, 0.5–1.2) or injury burden (RR, 90%CI = 0.8, 0.6–1.1).

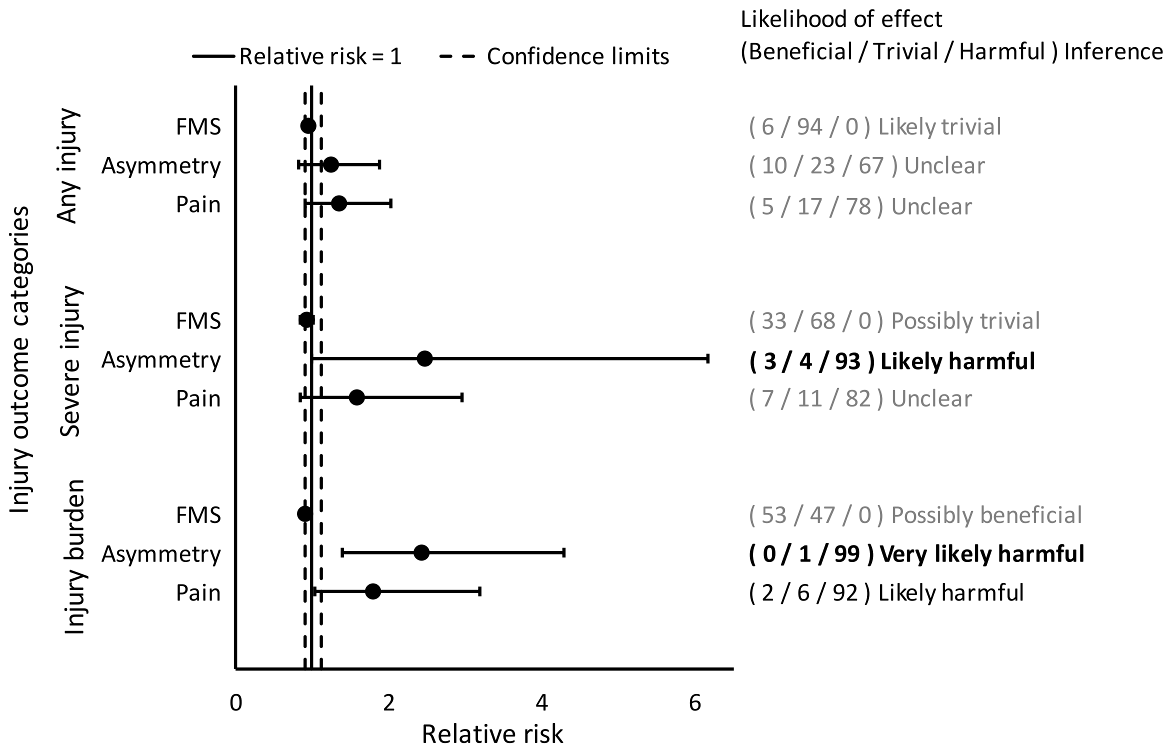

Figure 3.4. Forrest plot displaying univariate results for relative risk of injury for players with higher FMS score (continuous) compared to lower FMS score; players displaying any asymmetry compared to players with no asymmetry; and players reporting pain to players not reporting pain. The largest effects are highlighted in bold.

As the presence of asymmetry (Y/N) and/or pain (Y/N) were strongly associated with injury outcomes during univariate analysis the interaction between pain and asymmetry was investigated. For this analysis, the baseline group for comparison included players who did not present either pain nor asymmetry (n = 64, 23%) for whom the incidence of severe injury was 3.7 (90%CI = 3.3-5.1) injuries/1000 player match-hours and injury burden was 291 (90%CI = 257-403) days/1000 player match-hours.

Reporting pain without displaying asymmetry (n = 12, 4%) was associated with an unclear 1.4 times incidence of severe injury (RR, 90%CI = 1.4, 0.2-12.4) and a likely harmful 1.4 times burden of injury (RR, 90%CI = 1.8, 0.5-6.5). Displaying asymmetry without reporting pain (n = 136, 49%) was associated with a likely harmful 2.3 times incidence of severe injury (RR, 90%CI = 2.3, 0.6-8.5), and very likely harmful 2.3 times burden of injury (RR, 90%CI = 2.3, 1.1-4.9). Presenting both asymmetry and reporting pain (n = 65, 23%) was associated with a very likely harmful 3.2 times incidence of severe injury (RR, 90%CI = 3.2, 0.8-12.4), and a most likely harmful 3.6 times injury burden (RR, 90%CI = 3.6, 1.5–8.9).

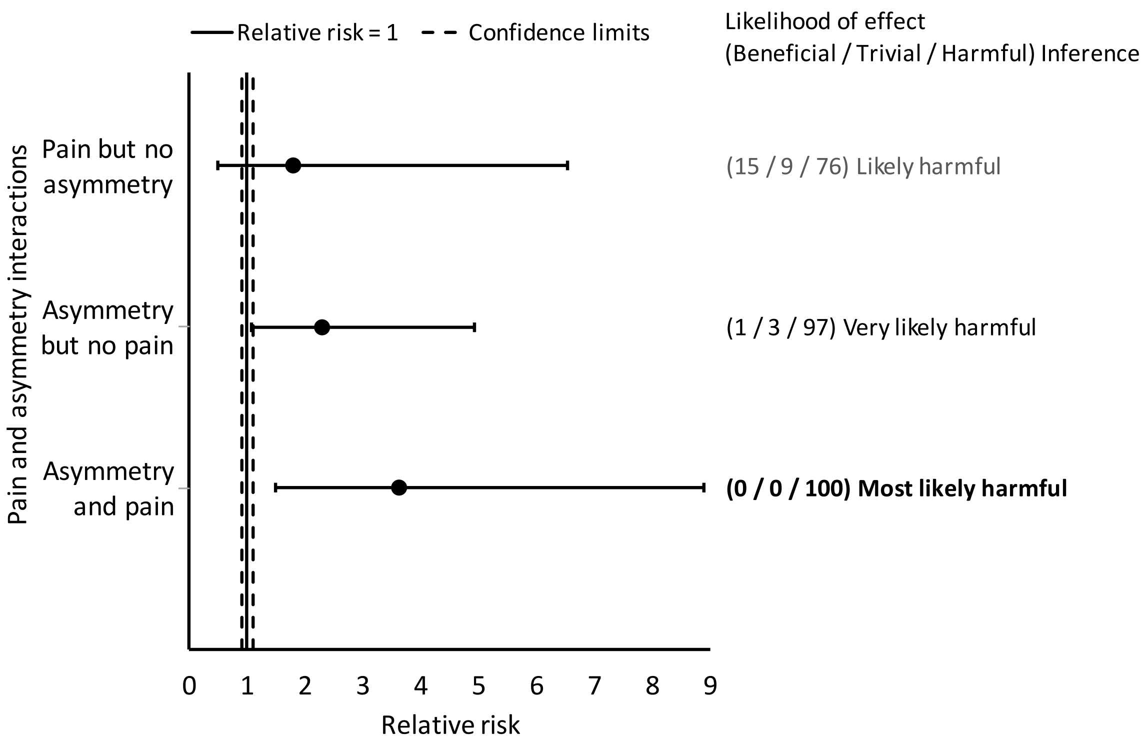

Figure 3.5. Forest plot displaying the interaction effects of pain and asymmetry on injury burden (days/1000 player match-hours) compared baseline (no asymmetry, no pain). The largest effects are highlighted in bold.

3.4 Discussion

This study investigated whether the Functional Movement Screen™ and FMS-determined pain and asymmetry were associated with time-loss match injury in men's community rugby players. The presence of both pain and movement asymmetry during FMS screening were associated with 3.6 times the injury burden and 3.2 times the incidence of severe injury compared to players with no pain or asymmetry. Asymmetry was the factor with the greatest association with injury outcomes. Players that demonstrated movement asymmetry were associated with 2.3 times the injury burden and 2.3 times the incidence of severe injury compared to players with no asymmetry. With respect to a 'cut-off' score, players with a FMS score ≥16 was associated with a very likely beneficial 60% lower injury burden compared to players with players scoring <16. Players with a score ≥16 were associated with a likely beneficial 50% lower severe injury incidence compared to players with FMS scores <16.

With respect to asymmetry, for American football players, the relative risk of injury (any training or match time-loss injury excluding contusion) for players displaying asymmetry was 1.8 (Kiesel et al., 2014), while for Australian rules football players the relative risk of injury (any trauma or medical condition resulting in match time-loss) for players displaying an asymmetry was 1.9 (Chalmers et al., 2017). In the present study, players presenting with ≥1 asymmetry were associated with 2.3 times the overall injury burden (664 vs 291 days/1000 player match-hours) and 2.3 times the incidence of severe injury (8.6 vs 3.7 injuries/1000 player match-hours) compared to players with no asymmetry. To date only one previous study has investigated the combination of asymmetry and pain with respect to injury risk. For youth Australian football players, players that displayed both pain and asymmetry had a likely harmful 1.6 times risk of time-loss injury (Chalmers et al., 2017) compared to players with no pain or asymmetry. In the present study players that reported pain and displayed asymmetry were associated with 3.6 time the overall injury burden (1054 vs 291 days/1000 player match-hours) and 3.2 times the incidence of severe injury (12.0 vs 3.7 injuries/1000 player match-hours) than players with no pain or asymmetry. The results of the present study support previous research that indicated associations between the presence of asymmetry and increased injury risk, where players who also reported pain had the greatest injury risk.

Detection of asymmetries in athletes as part of a screening battery is not a novel concept. Asymmetries such as strength asymmetry between the quadriceps to hamstrings (H:Q) determined by isokinetic dynamometer in professional footballers indicated players with H:Q asymmetry were 4.7 times the relative risk of hamstring injury compared to players without this asymmetry (Croisier et al., 2008). Asymmetry in internal to external isokinetic strength of the shoulder muscles (where eccentric external rotation was less than concentric internal rotation) in elite volleyball players was also determined as a significant risk factor for injury (Wang and Cochrane, 2001). However, testing using an isokinetic dynamometer is time consuming and the equipment is very expensive making such screening tests unaffordable by community rugby clubs. By comparison the FMS is relatively quick to administer and the equipment cost would not be unreasonable for many clubs. What is not apparent when conducting the FMS is why asymmetry or pain is present. Possible reasons could be related to hand and leg dominance, poor training practice or previous injury. Clubs using the FMS are advised to recommend players displaying asymmetry for further investigation by a medical practitioner to identify the underlying cause of the asymmetry, for which a pre-habilitation programme may be developed. Priority for such referral should be granted to players who display asymmetry and also report pain as these players were associated with greater risk of injury than asymmetry alone.

In the present study, players with a FMS score <16 were associated with 2.1 times the incidence of severe injury (9.5 vs 4.6 severe injuries/1000 player match-hours) and 2.4 times the overall injury burden (793 vs 325 days/1000 player match-hours) compared to players scoring ≥16. This FMS cut-off value is higher than the previous value of 14 suggested in previous studies in American football (Kiesel et al., 2007; Kiesel et al., 2014) and both experienced and professional rugby (Tee et al., 2016; Duke et al., 2017). There are a variety of factors that may have contributed to the higher cut of value in the present study including the sample population for which the injury rate is lower than the in professional game. In the present study players' match exposure was also considered during analysis whereby the cut-off was determined using a different statistical approach to the receiver operator characteristic analysis commonly employed in FMS literature (Butler et al., 2013; Chorba et al., 2010; Kiesel et al., 2007; Kiesel et al., 2014). However, as players displaying the combination of movement asymmetry and pain and players with the presence of asymmetry alone had greater associations with injury risk than the FMS composite score, these players should be the primary focus following athlete screening.

To date no study has measured players FMS scores and produced a pre-habilitation programme that has been demonstrated as effective in reducing the injury risk of the athletes. This is likely due to too many variables contributing to lower FMS scores such as limited range of motion, strength asymmetry or previous injury which are likely to be different for each individual, thus requiring an individualised approach to each player's pre-habilitation programme. Considering a physiotherapist working with a small team in an elite environment where staff resources are likely beyond that of a men's community rugby club, this may be feasible. However, the present study demonstrated that almost 80% of players had ≥1 asymmetrical movement patterns. The task of screening all players, re-assessing those highlighted as being 'at risk' in order to implement a pre-habilitation programme seems unreasonable given the often limited resources available to community rugby clubs. Rather than screening players and developing individualised programmes based on low FMS scores, a more effective approach to reducing injury in rugby may be to administer preventative exercises to all players during training, as preventative exercise has been demonstrated to be efficacious in sports such as football (Gilchrist et al., 2008; Emery and Meeuwisse, 2010; Soligard et al., 2008), basketball (Longo et al., 2012) and handball (Olsen et al., 2005; Andersson et al., 2016).

3.4.1 Conclusion

Functional movement screening during pre-season can be used by practitioners identify players at greater risk of injury. Practitioners should prioritise players displaying both painful and asymmetrical movements as these factors combined presence was strongest injury risk factor. A FMS score of ≥16 was associated with a 60% reduction in time-loss from match play, and may provide athletic training staff a useful target for players to achieve during pre-season training.

CHAPTER FOUR

DEVELOPMENT OF A MOVEMENT CONTROL INJURY PREVENTION EXERCISE PROGRAMME: A NARRATIVE ACCOUNT

4.1 Introduction

Sports participation is widely accepted to be beneficial for participants' health and wellbeing (Pate et al., 1995) by reducing the burden of chronic disease (Coombes et al., 2015). As such adults are advised to participate in regular physical activity. As an example, rugby is recommended as a form of vigorous activity (NHS, 2015). In England rugby is played at least once a month by 279,000 adults (Sport England, 2016). However, participation in sport has an inherent risk of sports injury (Finch and McGrath, 1997) giving rise to its own economic burden (Ozturk and Kilic, 2013). The economic burden associated with sports injury has prompted efforts to maximise the benefits of exercise while minimising the risks of injury (Lauersen et al., 2014; Finch and Owen, 2001).

Two sport specific models of injury prevention have been developed; the sequence of injury prevention (van Mechelen et al., 1992), and Translating Research into Injury Prevention Practice (TRIPP; Finch, 2006). The first 4 stages of each of these models of injury prevention are similar and include: 1) establishing the extent of the injury problem; 2) establishing the cause and risk factors for sports injury; 3) the introduction of preventative measures, and 4) the evaluation of the effect of those measures (van Mechelen et al., 1992; Finch, 2006). TRIPP (Finch, 2006), has two further stages that involve the translation of the injury prevention measure from the 'ideal' condition such as that of a study (i.e., where factors associated with the sporting population are controlled by the research team) into injury prevention strategies that affect the population it was designed. This final stage of TRIPP allows the effectiveness of the injury prevention measure to be evaluated.

With respect to injury surveillance (the first stage of the models of injury prevention (van Mechelen et al., 1992; Finch, 2006) the epidemiology of English men's community rugby union (hereafter referred to as 'rugby') has been described (Roberts et al., 2013). For this population the incidence of match injury (≥8 days time-loss) was 16.9 (90%CI = 14.9–16.5) injuries/1000 player match-hours where the ankle, knee, shoulder, and head are the most commonly injured body sites (Roberts et al., 2013). Translating this injury rate to a club indicates each rugby team loses an average of 1 player to injury every 3 games, where the average injury takes players between 4 to 5 weeks to return to play (Roberts et al., 2013).

Research into injury risk factors (related to the second stage of the models of injury prevention (van Mechelen et al., 1992; Finch, 2006)) in rugby have indicated that increasing age, ethnicity, ≥40 hours of strenuous physical activity/week, playing while injured, hard ground conditions and the use of headgear were associated with increased risk of injury in community players (Chalmers et al., 2012). In professional rugby, high weekly training loads, week to week changes in training load (Cross et al., 2016) and the number of matches played in the present and previous seasons (Williams et al., 2017) are associated with changes in injury risk. These risk factors are predominantly external risk factors that may be modifiable through strategies including player education, ground preparation, and close monitoring and/or limitation of players match and training loads. With respect to internal risk factors, there is a growing volume of evidence indicating that poor movement competency among players (as determined using the Functional Movement Screen) is related to increased risk of injury in professional (Tee et al., 2016), experienced club (Duke et al., 2017) and community rugby players (Chapter 3). Importantly, injury rates for sports participants have been shown to be modifiable through movement competency based injury prevention exercise programmes (Lauersen et al., 2014). Previous injury prevention exercise programme studies have focussed on different sports including soccer (Gilchrist et al., 2008; Soligard et al., 2008; van Beijsterveldt et al., 2012; Steffen et al., 2013; Hammes et al., 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015) or basketball (Longo et al., 2012), or included females rather than males (Gilchrist et al., 2008; Soligard et al., 2008; Steffen et al., 2013). As the physical demands of rugby result in a different injury profile compared with soccer and basketball, development a movement control injury prevention programme specific to the injury profile of men's community rugby is befitting.

This Chapter provides a narrative account of the process oriented approach used during the development of a movement control injury prevention programme that reflected the injury profile of men's community rugby, prior to implementation in a cluster randomised controlled trail (Chapter 6).

4.2 Method

The third stage of the TRIPP model (Finch, 2006) is the development of preventative measures. Twelve main stages were followed to facilitate the development of the final injury prevention programme (Figure 4.1). Stages 1 and 2 from Figure 4.1 relate to information presented in Chapters 2 and 3, respectively. This narrative account details information pertaining to stage 3 to stage 11.

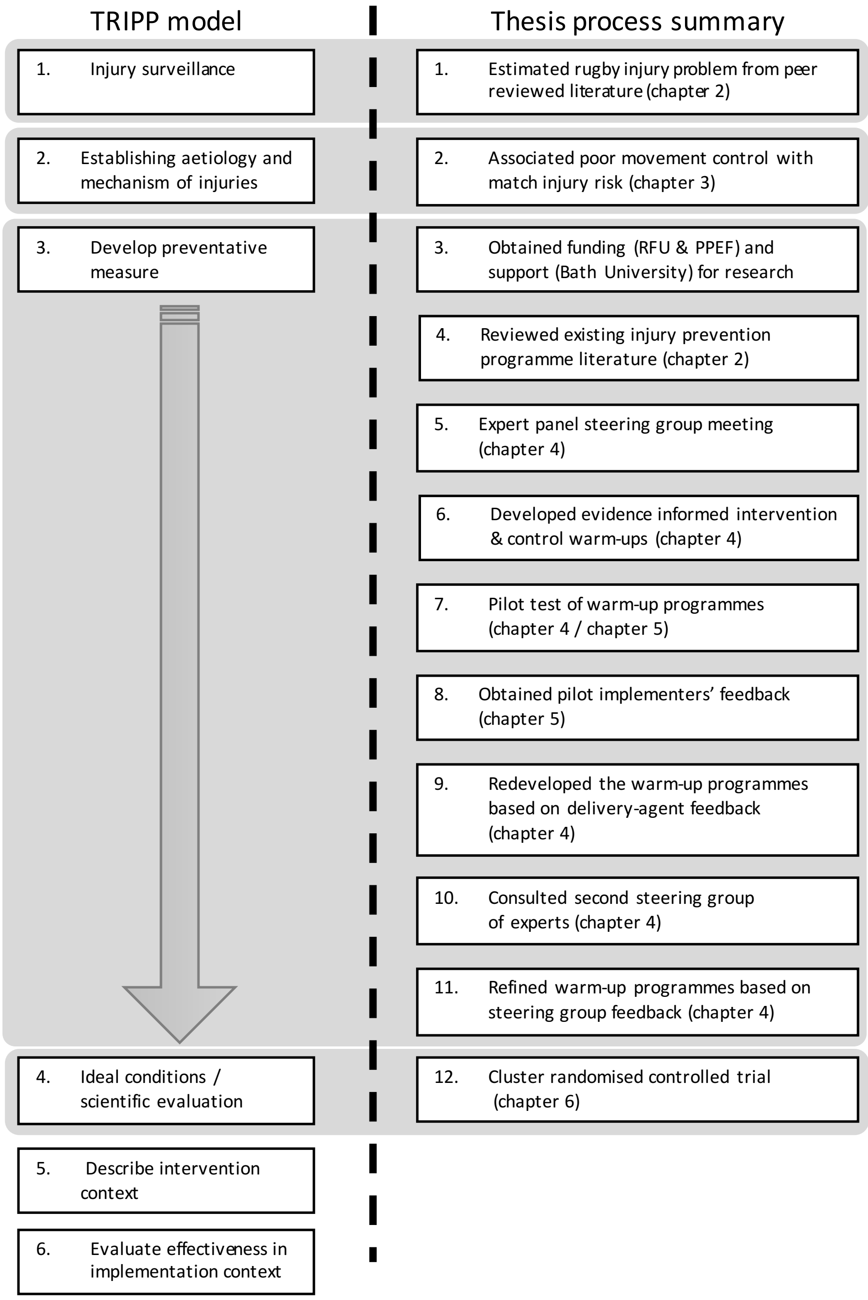

Figure 4.1 A summary of the process followed during the development of an injury prevention exercise programme for men's community rugby.

4.2.1 Stage 3 – Obtain funding and administrative support.

This series of studies were conducted by the author as a member of a research group, within which a leadership structure pre-existed and from which research support was received. Supported was also granted by the Rugby Football Union (RFU), who as the governing body for rugby in England, were a primary stakeholder with a specific interest in reducing injury in men's rugby. As these studies formed chapters of this PhD thesis, and because associated researchers had interests in the success of the overall project, clear leadership structure pre-existed. Additional funding for the programme of work was necessary and was obtained by this author from the Private Physiotherapy Education Fund, facilitating sustainability of the process in conjunction with support from the Rugby Football Union.

4.2.2 Stage 4 – Review of existing injury prevention literature

To inform the development of a rugby injury prevention exercise programme, an evidence based review of successful injury prevention exercises in a range of sports and settings was completed and up-to-date information on the epidemiology of community rugby was considered (Chapter 2). In English men's community rugby, the most prevalent injuries are lower-limb injuries (Roberts et al., 2013). The lower-limb is commonly injured in many sports, within which research investigating the efficacy of exercise based preventative measures using randomised controlled trials has been conducted (discussed in Chapter 2). Evidence supports the inclusion of eccentric strength (Arnason et al., 2008; Askling et al., 2003), balance (Verhagen et al., 2004; Emery et al., 2007) and plyometric exercises (Hewett et al., 2006; Gilchrist et al., 2008) for lower-limb injury prevention in sports including soccer (Soligard et al., 2008; Steffen et al., 2013), basketball (Longo et al., 2012) and handball (Olsen et al., 2005). A meta-analysis of injury prevention literature aimed at reducing knee ligament injuries demonstrated injury prevention exercise programmes that were multifaceted (OR = 0.32), that included strength (OR = 0.32) or core stability (OR = 0.33) were efficacious (Dai et al., 2012). As jumping, landing, cutting and sprinting tasks are common across the above mentioned team ball sports, exercises used in the prevention of injuries related to these movements may also be efficacious for use in an exercise prevention programme for rugby. As such a programme designed for rugby should include these elements.

Although most injuries occur to the lower-limbs, almost half of all match-injuries in men's community rugby are to the upper-body (Roberts et al., 2013). In rugby the predominant upper-body injuries involve injury to the shoulder (14% of all injuries; incidence = 2.3 injuries/1000 player match-hours) and the head (12%) and neck (4%) (head & neck = 16% of all injuries; incidence = 2.6 injuries/1000 player match-hours)(Roberts et al., 2013). In the development of a rugby specific prevention warm-up programme these injuries require specific attention. Overall, the shoulder is the second most injured site for men's community rugby players (Roberts et al., 2013), perhaps because the shoulder is used largely during contact events such tackling and rucking. The impact nature of tackle events in rugby most likely explains the substantial difference between the proportion of injuries involving the upper-limb in soccer to that of rugby, being 5% and 25%, respectively (Falese et al., 2016; Roberts et al., 2013). Research has demonstrated the ability of a mobilisation strengthening programme to reduce overuse shoulder injuries (Andersson et al., 2016) but there is no evidence in the literature regarding prevention of acute shoulder injuries (Steffen et al., 2010).

The glenohumoral and acromioclavicular joints are both considered under the term 'shoulder' injury within rugby literature (Roberts et al., 2013; Singh et al., 2016). An important difference between these two joints that requires consideration before designing an exercise programme to prevent shoulder injuries is that the glenohumoral joint is supported and stabilised by the surrounding muscles, while the acromioclavicular joint is not. As such injury to the acromioclavicular joint may be difficult to prevent through exercise measures. The three most common shoulder injuries are glenohumoral joint sprain and dislocation (39% of all shoulder injuries), acromioclavicular joint injuries (34% of all shoulder injuries), and shoulder tendon injuries (11% of all shoulder injuries) (Singh et al., 2016). Following glenohumoral joint dislocation, 81% of players suffer a secondary injury, with the predominance being to the rotator cuff muscles (Lynch et al., 2013) leading to glenohumoral joint instability. Weakness of rotator cuff muscles has been highlighted as a risk factor for shoulder injury in collegiate rugby players (Ogaki et al., 2014) which was demonstrated to be modifiable through resistance training in overhead athletes (Niederbracht et al., 2008). Functional improvements from resistance training may help prevent dislocation, improve recovery time following injury, as well as prevent sub acromial impingement (Spitzek, 2015). As such an injury prevention programme for rugby players should incorporate rotator cuff strengthening and shoulder stabilisation exercises.

4.2.3 Stage 5. – Consult injury prevention experts

In preparation for a 'sister' pilot study in youth rugby, an interdisciplinary steering group provided programme input. The steering group consisted of highly experienced researchers and practitioners working in the field of injury prevention, including;

Carolyn Emery	Professor in Injury Prevention at the University of Calgary
Evert Verhagen	Associate Professor in Human Movement and Injury epidemiology at the VU University Medical Center and the EMGO+ Institute in Amsterdam
Des Ryan	Head of Sports Medicine & Athletic Development at Arsenal FC Academy
Mike England	RFU Community Rugby Medical Director
Kate Davis	Physiotherapist to RFU England U18
Richard Mack	Head of Sports Medicine at Bath Rugby
Shaun Williams	University of Bath teaching fellow in sports coaching and rugby coach

The outcome of the steering group discussion supported the inclusion of the series of proprioceptive, mobility and strengthening exercises within a progressive exercise programme proposed by the research group. While youth rugby injuries are less frequent than adult rugby injuries, the proportion and nature of injuries to the lower-limb, head and neck and shoulder are very similar (Bleakley et al., 2011). This steering group did not directly focus on a prevention programme in men's rugby; feedback from the steering group was shared within the rugby research team and supported decisions made regarding the inclusion of similar exercises in the men's programme.

4.2.4 Stage 6 – Develop the pilot intervention and control exercise programmes

The pilot warm-up programmes were designed to be delivery-agent led programmes. In men's community rugby clubs, the person who normally takes the warm-up is the rugby coach or strength and conditioning coach (i.e., the delivery-agents). As such delivery was targeted at the delivery-agent to reflect the normal context of men's community rugby, reflecting clubs normal practice, and minimising organisational change. A group based, coach led programme, rather than individual self-led programme, can also facilitate compliance (Engebretsen et al., 2008). Exercises may be more effective when performed under supervision (Soderman et al., 2000), and group based programmes are suggested to facilitate player's programme engagement reducing the risk of players becoming bored by performing tasks individually (Engebretsen et al., 2008). To boost compliance, delivery-agents were also provided with a variety of programme tools to facilitate programme delivery (Soligard et al., 2008; Steffen et al., 2008; Longo et al., 2012). Programme tools included A4 size laminated cue cards that could be used in wet weather conditions, a detailed programme manual that expanded the detail regarding how to perform exercises, and video resources, accessible through the internet via, computer, or other electronic device including phones and tablets.

Previous injury prevention randomised controlled trials have relied on a natural control group, where teams were asked to continue with their normal practice during a warm-up (Gilchrist et al., 2008; Soligard et al., 2008; van Beijsterveldt et al., 2012; Hammes et al., 2015; Owoeye et al., 2014; Silvers-Granelli et al., 2015). Leaving teams to act as they see fit grants teams the potential to practice exercises not dissimilar as those provided within an intervention. Teams may also not perform a warm-up before training, or perform a warm-up not matching 'best practice' such as the raise, activate, mobilise and potentiate (RAMP) format advised by Jeffreys (2006). Another study design approach is to provide teams in the control arm of a study with a 'best practice' warm-up using the RAMP format and to provide teams in the intervention arm the evidence informed injury prevention warm-up. This facilitates an assessment of the efficacy of warm-up components specific to each programme to be compared with greater confidence.

For the present study, two different exercise programmes were constructed (intervention / control). The intervention warm-up reflected the injury profile of community rugby players. The intervention included forms of exercise demonstrated as efficacious in other sports and applied similar training principles to exercises chosen to target joints and muscles commonly injured in rugby. In contrast, the control warm-up comprised exercises not based on injury prevention evidence, but that met the RAMP format. Appendix *J* and Appendix K gives full details of the programmes piloted including progressions, exercise components, sets and repetitions. The intervention and control programmes were both designed to take 15 minutes to complete and both followed a RAMP (Jeffreys, 2006) format. Programme length was reported as a barrier to implementation when an intervention took 20 minutes on top of normal training (Cumps et al., 2008). As such for the pilot study, the warm-up duration was 15 minutes. Fifteen minutes was considered a sufficient duration to achieve a warm-up, i.e., raise body temperature, mobilise muscles and joints, increase heart rate, as well as complete movement control exercises, without demanding too much time from clubs training sessions. Both programmes were delivery-agent led (the delivery agent was normally a rugby or strength and conditioning coach) warm-ups that were designed to be implemented at the start of normal training (twice weekly) and before matches (once weekly). The recommendation for 3 times weekly practice of the intervention was made as the benefit of injury prevention programmes is influenced by programme exposure, whereby significant reductions in injury rates have been demonstrated when interventions were performed at least twice weekly (Gilchrist et al., 2008; Soligard et al., 2008; Steffen et al., 2013).

Pilot intervention programme exercise components

The pilot intervention started with the same preparation tasks across each of the six phases. The programme prescribed three channel based running tasks to be performed over a 15m length (so it could be performed using the standard measures on a rugby pitch, between the touch line and 15m line), and involved swerve running, stride outs and straight line accelerations, interspersed with backward side skips. Following the preparation phase, the pilot intervention included six progressive training phases that included: proprioception and balance exercises, mobility, resistance and plyometric exercises, with controlled rehearsal of landing and/or cutting movements with accompanying verbal feedback regarding technique. Progression across the phases occurred via a combination of the required sets and repetitions of an exercise, and an increase in the complexity or musculoskeletal load. Balance and proprioception training included static (i.e., single leg stand) and dynamic (jumping and hopping) exercises. Resistance exercises focussed on the anterior (e.g., bodyweight squats) and posterior thigh (e.g., bridge and Nordic hamstring exercise), using isometric, concentric and eccentric muscle actions, with varied time under tension, to exhibit increase in training load and volume. Upper-limb exercises included static resisted internal and external rotation exercises, reactive strength and stability shoulder exercises (e.g., shoulder workout/partner press-ups), and progressed to through range eccentric resistance exercises for the shoulder. Initially, cutting and landing exercises were isolated and pre-planned (e.g., 180 jumps), and progressed to unanticipated / reactive exercises (e.g., partner mirroring).

Pilot control programme exercise components

The control programme included six progressive training phases that included: dynamic stretching, and non-targeted, whole body resistance exercises presented in a similar progressive format to the intervention. The control programme was distinct from the intervention by excluding: balance and proprioception exercises, hamstring specific resistance exercises, progressive shoulder resistance exercises, jumping and landing technique exercises, or feedback during cutting type exercises. Exercises for the control programme were exercises sourced following internet searches for ‘rugby warm up’, and was designed to reflect ‘good practice’. Following the same preparation phase as the intervention, the control programme included a range of dynamic stretching and mobility exercises (e.g., hamstring walks, carioca). This progressed to whole body resistance exercises (e.g., cheek touch & kneeling wrestling) and finished with speed and agility drills where coach feedback cues were not provided (e.g., kneeling start sprint).

Phase duration

Drawing specific focus to the intervention programme’s exercises, 5 weeks is sufficient for significant improvements in balance following a balance training programme in healthy individuals (Heitkamp et al., 2001). For strength and neuromuscular adaptation, periods of 3 to 4 weeks is sufficient for adaptation to strength training programmes in men (Staron et al., 1994; Seynnes et al., 2007). Community rugby players’ training attendance is intermittent in nature, which is reflective of amateur sport (Finch et al., 2014). As such, players with intermittent attendance will require a longer period of time to gain sufficient programme exposure to stimulate the intended physiological and neurological responses. In consideration of players’ intermittent training attendance, both intervention and control programmes employed 6-week phases. A six week phase duration was considered sufficient time to facilitate players’ programme exposure (including players with intermittent attendance), enabling players to develop movement competency skills and enable strength adaptation to occur, while not becoming boring or monotonous for players which is a barrier to programme compliance (O'Brien and Finch, 2016).

4.2.5 Stage 7. Feasibility pilot of warm-up programmes

Compliance with prevention programmes has been recognised as a barrier to injury prevention (Steffen et al., 2008; Soligard et al., 2008). As such, a season-long feasibility pilot trial was conducted (detailed in Chapter 5) to inform development of strategies to maximise programme implementation in preparation for a cluster randomised controlled trial. Chapter 5 details information pertaining to barriers and facilitators to clubs' programme implementation, attained through interviews with club delegates. The interviews obtained feedback on the programme delivery by the research team, programme tools facilitating clubs' implementation of the programmes, and delivery-agents' feedback regarding the appropriateness of the exercises for the context of community rugby clubs.

For the pilot study a total of 16 community clubs were recruited and randomly allocated to either the intervention or control exercise groups. Fourteen teams actively participated in the study, and at the end of the season 7 teams (3 intervention, 4 control) were still actively engaged in the programme. This represented a 50% drop-out rate which was used to establish sample size estimates for the randomised controlled trial (Chapter 6).

4.2.6 Stage 8. Observations and feedback following pilot programme implementation

Implementation barriers have been grouped into categories including time, personnel and environment (Padua et al., 2014). These categories were linked by Padua and colleagues to their intervention programme. In Table 4.1 these categories are applied to reflect perceived barriers to conducting a cluster randomised trial as identified during the pilot trial period by the principle researchers (MA & SR) and from club delegate interviews (Chapter 5).

Table 4.1. Time barriers identified from pilot study field notes and research team reflections following the pilot study period (table 1 of 3).

Time
Barrier: From the end of the season (normally April) many clubs close until the preseason period (normally July). During this time club delegates are difficult to contact for recruitment. [reflection] **Solution**: For clubs to be in receipt of the programme early in the pre-season period, recruitment efforts must begin before the previous competitive seasons ends. This did not happen in the pilot study, meaning no single team was able to implement the programme a minimum of 5 weeks before competition.
Barrier: Clubs indicated resistance to receiving programme training other than on their normal training days. This limited delivery opportunities primarily to Tuesdays and Thursdays which are typically when teams train. [reflection] **Solution**: Based on this information, the time needed to deliver the programmes to a sufficient number of clubs was estimated. The limited number of research team members available to deliver the programmes required programme delivery for the full CRCT to commence from the beginning of June 2015. A June delivery would facilitate players' exposure to the programme for a minimum of 5 weeks before the competitive season started.
Barrier: Time was necessary for the recruitment and training of the programme trainers. Recognising the two research team members primarily involved in conducting the pilot study (16 clubs) would be insufficient to deliver to the 80 clubs needed for the CRCT, time was needed to recruit and train the trainers who collectively were responsible for programme delivery to clubs. [reflection] **Solution**: To enable programme delivery in June, recruitment for programme trainers commenced in April. Training of the 'programme trainers' was completed in May.
Barrier: Time was necessary to analyse feedback from pilot clubs regarding barriers and facilitators to the programme in order that feedback can be acted upon before training of the programme trainers. [reflection] **Solution**: Interviewers completed all interviews by the end of February. Field notes were compared and initial data analysis was performed in March, informing re-development of the exercise programmes, club recruitment (which began in April 2015) and the delivery strategy (from June 2015 onwards) for the main trial.

Table 4.1 (continued) Personnel and environment barriers identified from pilot study field notes and research team reflections following the pilot study period, and details of the solution applied (table 2 of 3).

Personnel

Barrier: Personnel required for programme delivery. Research team members (MA, SR) would be unable to facilitate delivery to all necessary clubs within the available time frame between recruitment and the start of preseason. [reflection]

Solution: A further 6 trainers were recruited from the Department for Health (University of Bath) to facilitate programme delivery to clubs. Programme trainers included one post-graduate (OP), two graduate (PB, FW), and three undergraduate Sport Science students (MW, DJ, AG). This provided a total of eight programme trainers including the two research team members (MA, SR)

Barrier: Transience of club staff. Programme delivery that involved training of the club coach only, was inadequate for a 3 (21%) pilot clubs due to transience of club staff members, which led directly to drop-out. [Chapter 5].

Solution: To improve peer education at clubs and to prevent where possible the influence of trained staff members leaving a club, multiple club representatives were targeted for receipt of the delivery of the CRCT. This was based on feedback from pilot club interviews that identified a lack of peer education and transience of staff as barriers to implementation (Chapter 5).

Barrier: Programme delivery during the club's off-season, where many representatives are absent will be a barrier to delivery. As such clubs may confirm a programme delivery date at short notice due to difficulties in organising their personnel. [reflection]

Solution: To facilitate programme delivery to a club at short notice, at least one programme trainer was left available during the delivery period, after allocating programme trainers to other clubs. This facilitated clubs receipt of programme training at short notice.

Environment

Barrier: The geographical location of clubs. As all English community rugby clubs will be invited to participate, participating clubs could span the length and breadth of England including Channel Islands and Isle of Mann for example, which will provide logistical barriers to the team of trainers. [reflection]

Solution: During programme trainer recruitment, priority was given to candidates who had vehicular access, and confirmed sufficient availability to facilitate travel over multiple days, including overnight stays away from family.

4.2.7 Stage 9. Re-development of the exercise programmes

The exercise programmes were redeveloped following feedback from delivery-agents who implemented the programme during the pilot study (Chapter 5). Feedback from the delivery-agents indicated that:

- Most teams would start training with touch rugby (a form of rugby where touching the opposing ball carrier replaces a contact tackle situation) prior to the exercise programmes
- Teams liked the structure and progression of the exercise programmes
- The 6-week period of each phase was sufficient to allow teams to become competent at the exercises without becoming bored;
- Teams liked the continuity of similar exercises between phases which enabled a smooth transition from one phase to the next without needing dramatic changes to their routine
- The exercise programmes were felt to be appropriate preparation for the players.
- In the intervention programme certain blocks of exercises made the exercise programme “too static”
- In the intervention programme more movement based exercises were wanted where players move in space.
- In the intervention programme, eccentric shoulder exercises were generally disliked and static shoulder exercises were preferred
- While ground based exercises in the exercise programmes were good, delivery-agents felt they were not appropriate for when the weather was bad and the ground was either wet or frozen and these ground based exercises were often left out in such instances.

For the randomised controlled trial the warm-up programmes were adapted to minimise ground based activities where players would be laid or sat on the ground in both the intervention and the control programmes. In the intervention programme the frequency of movement based exercises was increased and eccentric shoulder exercises were exchanged for static exercises.

Details regarding clubs’ previous warm-up exercises were obtained from clubs’ delivery-agents (Table 4.2). Details provided by club delegates confirmed that the exercises provided in the control programme were a true reflection of their previous normal practice, though the control programme provided a more structured approach than previously employed.

Table 4.2 A summary of feedback from pilot study clubs detailing previous warm-up duration and forms of exercise.

		Intervention n = 5 clubs	Control n = 4 clubs
Previous Warm-up Duration			
	5-10	1 (20%)	1 (25%)
	10-15	3 (60%)	1 (25%)
	>15-20	-	2 (50%)
	20+	1 (20%)	-
What type of exercises did your previous warm-up consist of?			
	Ball handling drills	1 (20%)	2 (50%)
	Touch rugby	5 (100%)	3 (75%)
	Movement based exercises	3 (60%)	1 (25%)
	Dynamic stretches	5 (100%)	2 (50%)
	Static stretches	4 (80%)	1(25%)
	Contact drills	1 (20%)	-
Did you incorporate injury prevention exercise previously?			
	Yes		
	Static Stretching	-	-
	Dynamic stretching	3 (60%)	2 (50%)
	Game specific drills*	-	1 (25%)
	No		
	Dynamic stretching	2 (40%)	1 (25%)
Who led the previous warm-up?			
	Coach or player	1 (20%)	2 (50%)
	Always a Coach	3 (60%)	2 (50%)
	Always a Player	1 (20%)	-

*Game specific drills included tackling tackle bags, scrummaging with a scrum machine.

4.2.8 Stage 10. Consult the specialists

The modified exercise programme was assessed by a technical review group of exercise and injury prevention specialists including:

Prof. Keith Stokes	Principal Investigator on the project
Dr Carly McKay	Researcher in sports injury prevention with expertise in human behaviour
Dr Simon Roberts	Rugby epidemiologist and assistant researcher on the project
Rich Mack	Head of Sports Medicine at Bath Rugby
Vincent Singh	Head of Sports Rehabilitation at University of the West of England
Paul Tompkins	Former head Physiotherapist to Bristol Rugby
Tim Lawrenson	Accredited Strength and Conditioning Coach (UKSCA)

The technical review group discussed the flow of the programmes exercises and the appropriateness of each programme for men's community rugby players. A second focus was to ensure sufficient difference between the exercise properties of the programmes. The exercise programmes received final modifications following the group's input. A summary of points raised by the technical review group is detailed in below:

- The information regarding touch rugby should state that teams are limited to groups of six rather than everyone playing in the same game. By reducing numbers per team, players involvement and thus the benefit of touch rugby as a pulse raise exercise will increase
- Intervention programme exercises were still too static and required re-organisation to increase frequency of player movement. Potentially start with little movement after the initial pulse raise exercises and gradually increase the movement throughout.
- In the intervention programme, neck muscle strength should be included due to potential links with reducing concussion.
- Intervention exercise cues can be improved adding greater detail with respect to body alignment
- In the intervention programme variation between phases should be minimised to optimise the adaptation / impact

- In the intervention programme eccentric hamstring / posterior chain exercises should be included from the first phase replacing more isometric exercises, i.e., removing bridge exercise and replacing it with a hip aeroplane exercise.
- The intervention would benefit from inclusion of ankling exercises such as ankle pogo jumps/hops due to links with tendon stiffness. Tendon stiffness aids load acceptance and may be beneficial for reducing Achilles tendinopathy.
- In the control programme, leg swing exercises in frontal and sagittal planes may offer too great a balance and eccentric component. These should be removed to maintain a clear difference between types of exercise used in the programmes

All feedback points were implemented and changes contributed to the final intervention and control programmes. The most significant change following the technical review group meeting was the inclusion of neck resistance exercises in the intervention programme, as no neck exercises were previously included.

4.2.9 Stage 11. The final exercise programmes

The final intervention and control exercise programmes are displayed in Appendix *O* and Appendix P. Both exercise programmes followed a raise, activate, mobilise and potentiate (RAMP) format (Jeffreys, 2006). The exercise programmes were designed to be completed at the start of each training session and would each last up to 25 minutes if teams chose to use the full 10 minutes allocated to small sided games. The use of small-sided games such as touch rugby was recommended as a fun pulse raising introduction to each programme. Incorporation of the rugby ball also helps introduce the programmes as rugby specific from the beginning. Small-sided games were recommended to last for a minimum of 5 minutes up to a maximum of 10 minutes through all phases. This element was specifically included in response to the pilot study feedback where most pilot teams already used touch rugby at the start of training allowing the arrival of less punctual players and may improve player buy in and ultimately club compliance due to players familiarity with the programmes. Following the pulse raise exercises the main content of each programme was distinctly different, before both ending with repeated shuttle runs.

The intervention programme

The final intervention incorporated balance / proprioceptive exercises, resistance and perturbation exercises, and sport related landing, cutting and plyometric exercises. Proprioception and balance exercises progressed through alterations including the use of upper-limb movement, performing the exercises with eyes closed so removing the visual component to balance, and by perturbations in frontal and sagittal planes. Dynamic stability exercises targeting upper and lower limbs progressed in load by altering the number of sets and reps, intensity and by variations in the directions of movement. Resistance exercises progressed in duration or intensity as well as by altering the type of muscle contraction to include isometric, concentric and eccentric muscle activity. Landing, cutting and plyometric exercises varied phase to phase but reflected sport specific skills such as jumping to catch a high-ball and progressed in their difficulty. Variations included progressing from a single cutting manoeuvre to a cut, spin and accelerate movement pattern. Plyometric exercises progressed through each of the phases beginning with lower load double-legged tasks to high load single-legged tasks. Throughout the intervention warm up there was a consistent theme of quality of movement control and body alignment for delivery-agents to feedback to the players.

The control programme

Following the pulse raise activity, the final control programme content included dynamic stretching and mobility exercises followed by resistance exercises. Dynamic mobility exercises were similar throughout the programme's phases, including the use of 'hamstring walks' and 'arm circles'. While this did not present a progression, it did reflect current practice based on delivery-agents' feedback. Resistance exercises did include progressions using variations in sets and reps to adjust load, and variation of similar exercises such as sit-ups, crunches and V-sits that all target similar muscle groups. The variation was considered important to minimise programme stagnation while also increasing in difficulty thus offering players more of a challenge.

4.3 Summary

Development of injury prevention programmes is an integral stage in sports injury prevention. This Chapter summarises key stages that were conducted during the development and refinement of an injury prevention exercise programme for men's community rugby union. This is the first detailed account that demonstrates challenges faced during the development of a movement control exercise intervention and the solutions to those challenges. This evidence informed development process assessed how suitable a movement control exercise intervention was to the sport context it was designed for and was a significant investment necessary to maximise the injury reduction benefit for men's community rugby.

Stage 12 (Chapter 6) is the final stage included in this thesis and will evaluate the efficacy of the final movement control exercise intervention that was developed throughout this Chapter. The overarching aim is to produce a programme which is effective outside the remit of a controlled trial, though assessment of the effectiveness of the intervention programme is beyond the remit of this series of studies.

CHAPTER FIVE

BARRIERS AND FACILITATORS TO IMPLEMENTING STRUCTURED WARM-UP PROGRAMMES IN MEN'S COMMUNITY RUGBY UNION.

5.1 Introduction

Sports injury prevention programmes can be efficacious in reducing sports injury incidence (Lauersen et al., 2014). The efficacy of prevention programmes is influenced by compliance which can be defined as the proportion of sessions completed per protocol (McKay and Verhagen, 2016). Compliance is determined by the degree to which an intervention was accepted and adopted by club coaches and administrators ('club compliance') and the rate of uptake and usage of an intervention by each player ('player compliance') (Soligard et al., 2008). Randomised controlled trails have demonstrated the effects of compliance on injury rates when investigating the effects of the FIFA 11+, for example, in a randomised controlled trial investigating the effect of the FIFA 11+ on injury rates in youth female soccer players, players with high programme compliance had a 35% lower risk of all injuries compared to players with intermediate compliance (Soligard et al., 2010). A review of compliance within sports injury prevention programme studies indicated that while compliance significantly affected the study outcomes only 19% analysed the effect of compliance rates on study outcomes (van Reijen et al., 2016).

Factors affecting compliance with an exercise programme need investigating prior to large-scale implementation and assessment of prevention programme impact in real world settings (TRIPP stage 4; Finch, 2006). Understanding factors affecting compliance helps reduce the research-to-practice gap (Donaldson et al., 2016a), where factors affecting compliance are identified as primary determinants of successful injury prevention programmes (Hägglund et al., 2013a). Previously, players' views (Finch et al., 2014) and that of coaches (Saunders et al., 2010; McGuine et al., 2013) have been assessed using surveys that incorporated a mix of multiple choice, dichotomous (yes/no) and open-ended questions to gain information regarding implementation barriers and facilitators. O'Brien and Finch (2014) reviewed published implementation literature and summarised the reported barriers and facilitators to delivery-agent (i.e., the person responsible for delivering the programme, often the coach) adoption of injury prevention programmes in team ball sport trials. Barriers to delivery-agent adoption included: the requirement of data collection, contentment with the programme, a lack of interest, injury prevention being a low priority, lack of exercise variation, scepticism regarding programme effectiveness, and long follow up periods (O'Brien and Finch, 2014). Additionally, programme duration and exercises being too difficult for players have also been reported as delivery-agent barriers (Saunders et al., 2010). In contrast, facilitators included the incorporation of sport-specific exercises, the inclusion of endurance components (O'Brien and Finch, 2014), the perception of performance benefit and coaches' perception of reduced injury risk (Saunders et al., 2010).

To inform the development and refinement of intervention and control warm-up programmes (Chapter 4) before conducting a randomised controlled trial (Chapter 6), feedback from early implementers is recommended (Donaldson et al., 2016b). This study investigated factors affecting programme implementation, aligning with stage 4 from the TRIPP model (Donaldson et al., 2016b; Finch, 2006). This study will focus on the factors perceived by the delivery-agents as effecting their implementation of the warm-up programmes. The aim of this study was to enhance knowledge and understanding of barriers and facilitators to the implementation of delivery-agent led warm-up programmes in men's community rugby clubs. Delivery-agents' perceptions of, and suggestions to improve, the programmes' contents including the programmes' appropriateness for men's community rugby players was reviewed.

5.2 Method

The present study was conducted as part of a randomised controlled implementation pilot trial of rugby-specific, delivery-agent led warm-up programmes for men's community rugby. This study was performed alongside clubs' injury surveillance and assessment of warm-up programme fidelity that investigated the degree to which the warm-ups were implemented as intended. For the present study, semi-structured interviews were conducted to encourage delivery-agents to provide in-depth information and capture subjective meaning specific to men's community rugby (Kvale and Brinkmann, 2009). This study was approved by the Research Ethics Approval Committee for Health (REACH) within the Department for Health, University of Bath, UK (Ethical approval reference: EP 13/14 110) and written informed consent was obtained prior to interview.

5.2.1 Participants

A list of all rugby clubs registered with the Rugby Football Union (RFU) was collated, including clubs' current league and geographical location. For the pilot study, it was decided that clubs should be within a 75 mile radius from Bath University to ensure consistent contact could be maintained with the clubs and the research team could provide appropriate logistical support for the duration of the study. Additional inclusion criteria included: that clubs competed in one of the Rugby Football Union (RFU) leagues between levels 4 to 7; and that clubs had access to a qualified health care practitioner limited to the qualifications of Sports Therapist, Osteopath, Chiropractor, Physiotherapist or Physician, in order to formally diagnose players' injuries.

5.2.2 Randomisation

Clubs that met the geographical location criteria were listed in a randomised order (via random number generation) and emailed full participation information. Sixteen clubs was the maximum number of clubs the research team could sufficiently support during the study period due to the fidelity arm of the pilot study. With respect to the present study, all 16 clubs were recruited for interview to ensure the breadth of experience was accounted for.

A researcher, external to the research team, randomly assigned interested clubs to either the intervention or control group. Clubs were blinded as to the programme they received and were informed they were involved in a small study evaluating the efficacy of different combinations of exercises for injury risk reduction and that clubs throughout the area were using different exercise combinations. This was deemed a pragmatic approach to limit contamination due to clubs who, due to being randomly assigned, could be situated in close geographical proximity to one another. Double blinding was not possible, as the lead researchers were responsible for training clubs to use the warm-up programmes.

5.2.3 Pilot interventions

The pilot intervention warm-up consisted of an evidence-informed movement control programme including proprioceptive, balance, landing, cutting and eccentric exercises. The pilot control warm-up followed a raise, activate, mobilise and potentiate (Jeffreys, 2006) format incorporating whole-body dynamic stretching and resistance exercises, such as partner grappling, front-planks, press-ups and sprint drills. Both interventions were designed to take around 15 minutes to complete and employed 6-week cycles to maximise player exposure to the exercises and consequently allow time for players to develop movement competency skills and enable strength adaptation to occur. Both warm-ups were delivery-agent led and were recommended to be used 3 times weekly – including at training sessions (twice weekly) and pre-match (once weekly) (Chapter 4).

5.2.4 Programme training

Warm-up programme training was delivered to participating clubs by two 'programme trainers' (the lead researchers). Each club nominated a 'delivery-agent' who was responsible for delivering the warm-up within their club. During each club's programme training session, all written materials including exercise cards (a laminated A4 size sheet detailing each exercise for the respective phase) and an exercise manual (an in depth manual detailing each exercise and subsequent progressions in greater detail than the warm-up cards) were given to clubs along with practical demonstrations of the exercises. The programme trainers explained all report forms (player training attendance, player programme & match exposure and match-injury), including when and how to submit them to the research team.

5.2.5 Interview guide

A semi-structured interview guide was developed using an interpretive phenomenology approach (as opposed to grounded theory) where additional questions were not added to the semi-structured interview script following delivery-agent responses. The Semi structured interview included a mix of open and closed questions relating to implementation of the warm-up programmes. Examples of interview questions are displayed in Table 5.1 (the full questionnaire is in Appendix L).

Table 5.1 Examples of interviewer prompts used in semi-structured interviews

Representative's background and reasons for study involvement	Can you define your current role with the club for me? What skills and experience do you have that have 'qualified' you, formally or informally for your current role? Do you feel a focus on injury prevention, such as is the intention of this study, is necessary as this level of rugby? (Why? / Why not?) What has been your role with respect to the club's participation in the injury prevention programme study?
Factors modifiable by research team – i.e., resources, their provision and delivery	Do you feel that the research team delivered what you expected from your prior contact with the team during recruitment? Do you feel the resources could be improved in any way? How? Do you feel that the resources alone would have empowered you to deliver the injury prevention warm up without having the visits from the research team?
Factors affecting club's programme delivery	What if anything, affected your club completing the warm up? What would happen if the person who led the programme was ill/away? Are there any aspects of this programme that you thought were better / more successful than others? Why?

5.2.6 Interviews

Participating clubs' delivery-agents were informed of the purpose of the interviews and what they would entail when invited for interview in January (Figure 5.1), approximately 3 months from the end of the competitive season (6 months into the pilot study). This time was chosen as clubs' delivery-agents would have had sufficient time to experience multiple phases of their programme and thus be able to report on their on-going implementation experiences. Where clubs ceased implementing the programme or dropped out of the study, the interview facilitated reflection on experiences and their decisions to end participation. Respondents who expressed an interest in participating were contacted to arrange a suitable time and location for the interview. Interviews were conducted face-to-face. All conversations were audio recorded for transcription.

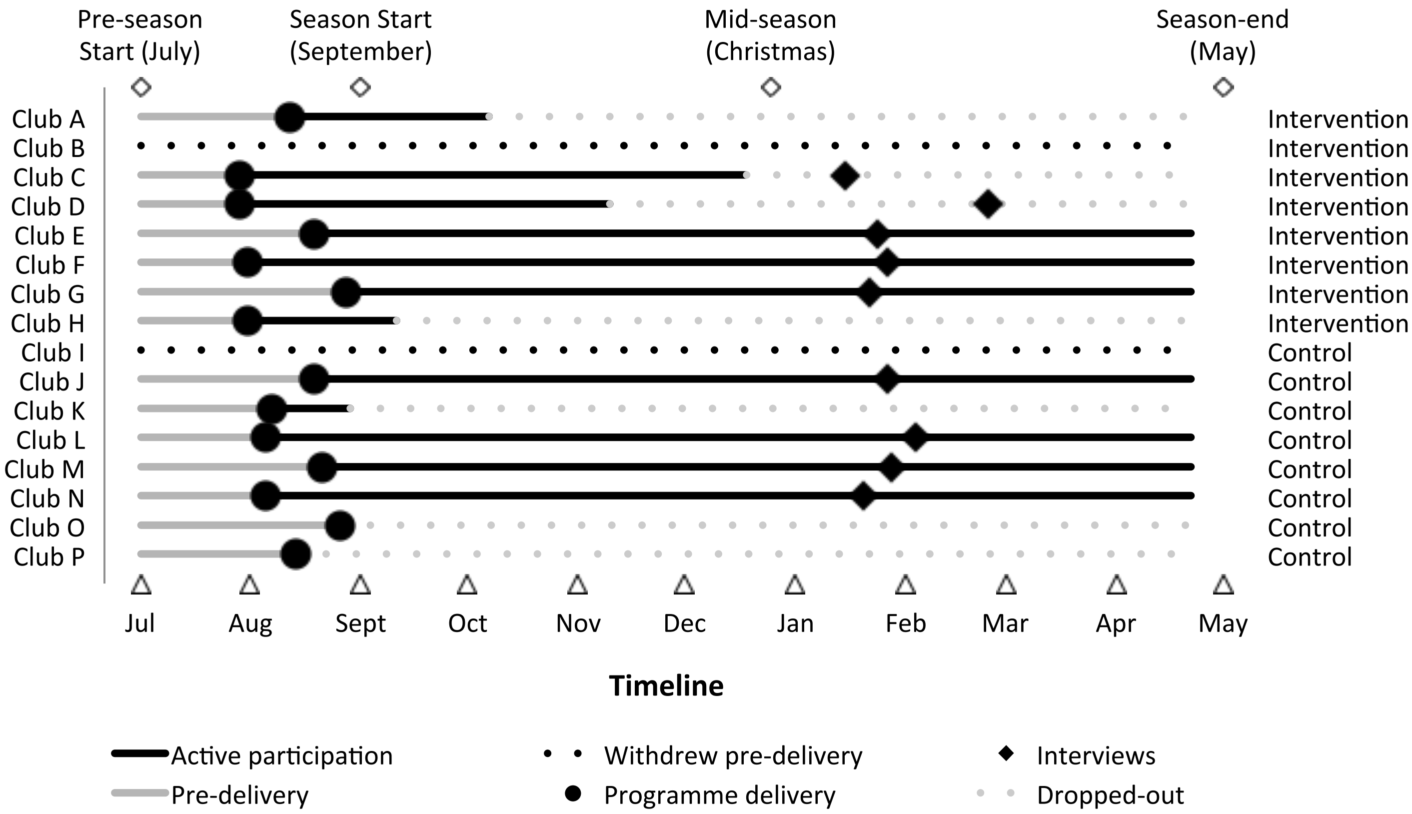

Figure 5.1. Timeline representation of community clubs' participation, detailing study arm (right most column), programme delivery to individual clubs, duration of club's participation, timing of interviews and time of drop-out.

Analysis

An audio recording of each interview was transcribed verbatim (by a trained transcriber) before initial transcripts were crosschecked and amended by the author. Framework analysis (Ritchie and Spencer, 2002) was employed and an inductive content analysis approach was used to organize quotes into meaningful themes and comprehensive categories. NVivo Version 10 (QSR International Pty Ltd, 2012) was used to assist with data analysis. Independent analysis was conducted by both the lead author and another researcher who was experienced in qualitative analysis (JR), but who was not part of the research team. All interviews were double-coded which enabled all themes and data interpretation to be cross-checked (Barbour, 2001). Identified themes were discussed by both researchers and where discrepancies were found, themes were discussed and modified accordingly. Once agreement was reached, all transcripts were reviewed until coding was complete.

5.3 Results

Fifty-six clubs were contacted to gain 16 clubs' expressions of interest, representing a reach of 29% of those clubs (Figure 5.2). Overall 14 (88%) clubs participated in the pilot study as two clubs withdrew their interest in pre-season before receiving any materials or training and subsequently did not contribute to the interviews. Delivery-agents from 9 different clubs (intervention n = 5, control n = 4) volunteered to be interviewed. These consisted of participating clubs (n = 7) and drop-out clubs (n = 2) that had all received the materials and training. Collectively, 14 delivery-agents were interviewed from the 9 clubs (head coach n = 8, player coach n = 3, assistant coach n = 2, and a player delivering the warm-up n = 1; Table 5.2). Interviews lasted between 14 and 48 minutes (median duration = 44 minutes), this variation reflected the time available to participants and the breadth of information given in participants' responses.

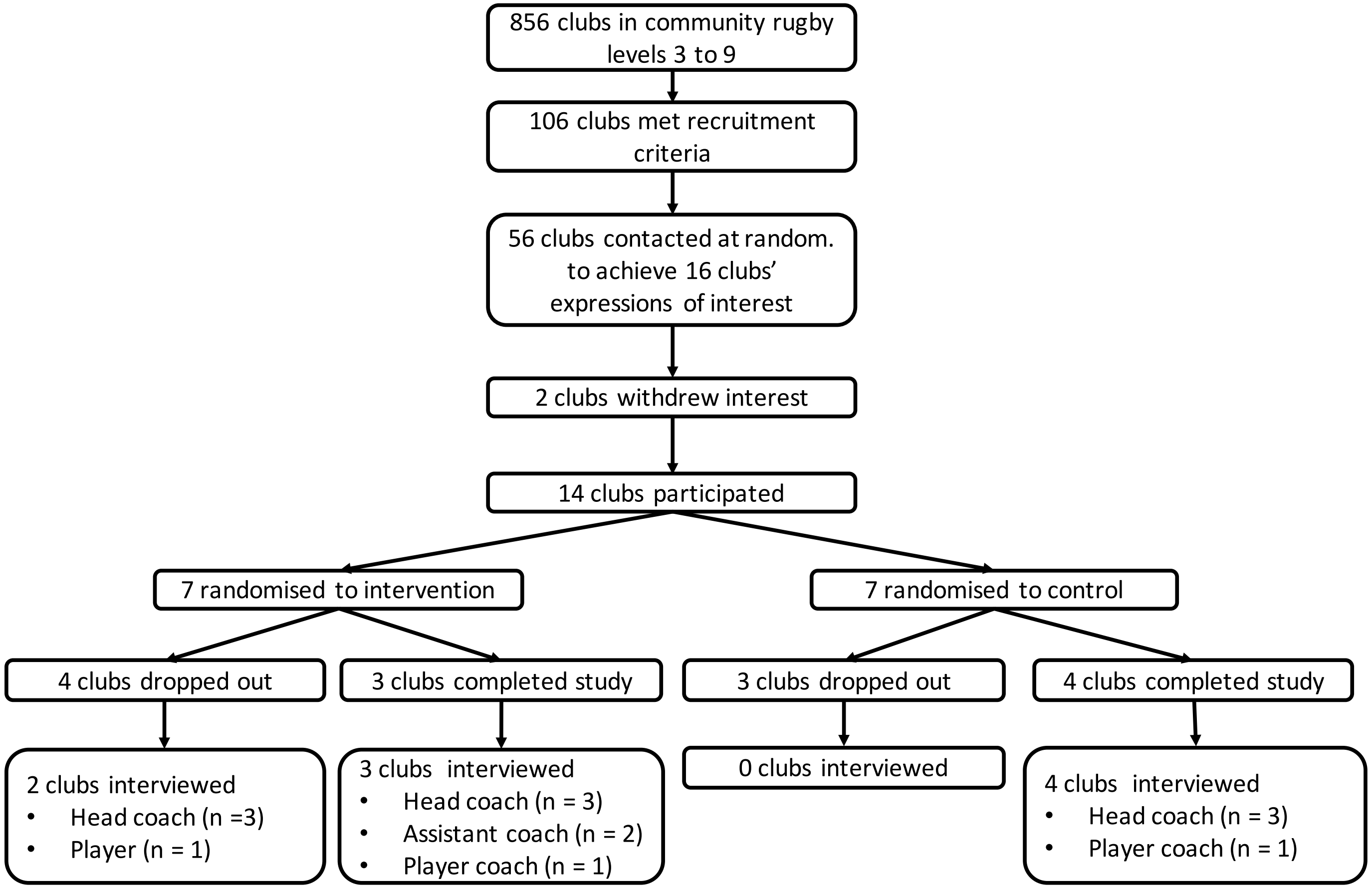

Figure 5.2. Flow diagram representation of the reach of the pilot study, and participation in interviews.

Table 5.2 Summary of roles and background experience of participants

		Intervention n (%)	Control n (%)
Roles			
Delivery-agent	Head coach	2 (20%)	2 (50%)
	Player coach	1 (10%)	2 (50%)
	Assistant coach	2 (20%)	-
	Player	1 (10%)	-
Other*	Head coach	4 (40%)	-
Experience & Background			
Time at club	<1 year	2 (20%)	-
	1-2 years	3 (30%)	1 (25%)
	3-5 years	3 (30%)	3 (75%)
	>5 years	2 (20%)	-
Coaching	No formal qualification	4 (40%)	-
	NGB Level 2	4 (40%)	3 (75%)
	NGB Level 3	2 (20%)	1 (25%)
Additional Roles & Experience	Rugby Development Officer	1 (10%)	-
	Rugby Coach Educator	2 (20%)	-
	Sports Teacher / Lecturer	2 (20%)	2 (50%)
	Military trainer	2 (20%)	-
	Ex-professional rugby player	2 (20%)	-
	None directly relevant	1 (10%)	2 (50%)

* Club delegates who were not the primary delivery-agent, but who were involved in warm-up delivery.
NGB = National governing body.

5.3.1 Facilitators and barriers to programme implementation

Factors identified as affecting warm-up implementation are listed in Table 5.3. Highly distinguishing factors that effected implementation were similar in both trial arms. All clubs' participation was due to delivery-agents wanting to invest in their players' welfare. Poor weather was the most commonly cited barrier to implementation while programme training and clarity of programme tools were the greatest facilitators to implementation success. The complex interplay of identified themes is discussed in the following sections.

Table 5.3 Themes coded inductively from semi-structured interviews including behavioural, environmental, personal and programme specific factors that effected warm-up implementation.

Factor		Response	Intervention n (%)	Control n (%)
Personal	Facilitator	Investment in player welfare	7 (70)*	4 (100)
		Self-efficacy	8 (80)*	4 (100)
		Good peer understanding	6 (60)	3 (75)
		Perceived benefits	3 (30)	2 (50)
	Barriers	Perception of programme duration	4 (40)	2 (50)
		Poor peer understanding	4 (40)	0 (0)
Behavioural	Facilitators	Positive club culture	4 (40)	1 (25)
		Strong leadership	4 (40)	1 (25)
		Team focus	3 (30)	1 (25)
		Team organisation	3 (30)	1 (25)
	Barriers	Team organisation	3 (30)	2 (50)
		Negative club culture	1 (10)	1 (25)
Programme specific	Facilitators	Programme tools	8 (80)*	4 (100)
		Programme delivery	8 (80)*	4 (100)
		Continuity of exercises	6 (60)	0 (0)
		6 weekly phase change	5 (50)	2 (50)
	Barriers	Ground based exercises	8 (80)*	4 (100)
		Too few movement based exercises	6 (60)	0 (0)
		Eccentric shoulder exercises	5 (50)*	N/A
Environmental	Barrier	Poor weather (rain and cold)	8 (80)*	3 (75)

* Highlights where responses represent 100% of clubs in intervention arm.
N/A = The Control programme did not contain eccentric shoulder exercises

5.3.2 Personal Factors

Investment in player welfare

In all instances, clubs' study participation was the result of delivery-agents wanting to invest in injury prevention to aid their players' welfare. Delivery-agents identified the warm-up as a potential measure to reduce player injury, but questioned their club's previous warm-up's effectiveness in this context. When delivery-agents were questioned about their club's previous warm-up practices and the rationale supporting the inclusion of the exercises that were included in these warm-ups, delivery-agents displayed limited knowledge of exercises evidenced as helping reduce injury. When questioned on their previous warm-up activities, one club incorporated small-sided games such as 'tag' while all other clubs played touch rugby:

> *"Normally a bit of a pulse-raiser, whether it be touch or some kind of game, whether it be end ball or rugby-netball … and then we'd probably do some dynamic stretching" (Intervention club)*

The pulse raising activity was commonly followed by dynamic stretching, though if players were given self-directed warm-up time, delivery-agents reported static stretching was commonplace:

> *"To be honest … it normally goes into static stretching when I would say to the boys you've got two or three minutes to do your individual stuff, I would say 90% of them would go straight into static stretching" (Intervention club)*

A summary of clubs' previous warm-up practices were detailed in Table 4.2 (Chapter 4).

Self-efficacy

When questioned whether delivery-agents felt able to deliver the programme with confidence following initial training, 100% of the responses were positive (Table 5.3). Delivery-agents described how having a good understanding on the programme, the programme's intended benefits and how to deliver the programme gave them confidence in their ability to deliver the programme as expected (self-efficacy), though a suggestion was made that immediate feedback on delivery-agents own delivery of the programme may improve this further:

"We were pretty confident after you showed us what to do but it certainly took two goes at it to get it right, if that makes sense. Potentially after the first one [initial delivery] if you watch us … and then provide some quick feedback to say you spent too long on this one or you didn't spend enough on that one or focus on this one." (Intervention club)

Self-efficacy of the delivery-agents appeared multifactorial, influenced by successful programme delivery by the research team, programme tools that were clear and easy to follow, but also appeared influenced by delivery-agents training and background and players understanding:

"…it was explained to them [the players] the reason why [rationale for an exercise] and I think a lot of them appreciated that…." (Control club)

"…they get it, they probably understand it more why they're doing this stuff …" (Intervention club)

However, poor understanding of the rationale for exercises following the first phase, particularly regarding eccentric shoulder exercises, also formed a barrier to implementation. This barrier was specific to the intervention arm and was relayed by delegates from 4 of the 5 intervention clubs:

"The shoulder mobilisation sort of stuff… wasn't so popular... Possibly some of the understanding of why they're doing the shoulder exercises, I mean they know it's to help them strengthen their shoulders but … I think they've enjoyed doing the ones that get them moving more …Because a lot of that is prehab stuff isn't it, so it's preparation to … well it's really to prevent injuries…And they probably see warm-ups as running around" (Intervention club)

Perceived benefits

Delivery-agents' perceived benefits were similar for both intervention and control warm-up programmes and the perception that the programmes were beneficial for the clubs re-enforced delivery-agents' motivation for engagement. Perceived benefits included club success, improved player focus at training and before matches, and reduced injury rates that, collectively, gave rise to positive club culture. Some of these sub-themes are described in the following sections.

Interplay of personal (player & delivery-agent self-efficacy; enjoying training) and behavioural (improved player focus, increased player attendance) factors were perceived by delivery-agents as promoting a positive environment within the club that was associated with teams' success:

> *"we're having our most successful season we've had here in ten years but could it be attributed to it [the warm-up]? … yeah. I mean you could well attribute that it's a structured warm-up that is in every training session, every game, they know what they're doing; less injuries. If you look at the bigger picture then yeah, it's probably had some contribution to the success of our season" (Intervention club)*

Team success was a highly distinguishing factor whereby the lack of team success, specifically poor league performance, was a barrier to implementation. Poor league performance resulted in reduced delivery-agent motivation for implementation and reduced player engagement in the programmes. Three clubs suggested that poor league performance led to an environment within their clubs that made implementation difficult and in two clubs this culminated in club's dropout from the study. Conversely two clubs that were content with their league performance attributed some of their success to having implemented the warm-up programme within their club as implementation resulted in better player focus during training and pre-match as well as increased availability of players through reduced injury rates compared to previous seasons. Four of the seven compliant clubs highlighted the intervention brought focus to their club's sessions (Table 5.3). Due to having a set routine, players' attendance and engagement during sessions improved, as did their punctuality at training sessions. In turn these behavioural changes improved the context of training sessions, freeing up time to work on specific skills, time that was otherwise wasted waiting for players to attend:

> *"it does mean that they focus better before games and they focus better at the start of training because they've all done the same thing [referring to the intervention] and they know what's coming up" (Intervention club)*

Programme duration

Programme duration was subject to conflicting views. All clubs suggested that a 15-minute exercise programme was ideal for their club. Two clubs suggested that the programme took them longer than 15-minutes to complete (17 and 20 minutes). However, half of the delivery-agents suggested the programme duration should be shorter. The interplay between factors including the static nature of movement control exercises, the increased focus necessary to perform movement control exercises and barriers associated with poor weather conditions appeared to affect the perception of time:

> *"the feedback we had again on Thursday was some [players] thought it was too long and .. said it actually felt like it was 30 minutes, that's just their perception of time to be honest….when we said well actually it was only 17 minutes, 'Oh, it just seemed longer than that'." (Intervention club)*

5.3.3 Behavioural

Club culture

Reciprocal interaction between delivery-agents and players influenced implementation. These interactions reflected social hierarchies within the clubs. Personal factors including coaching time at the club and delivery-agent experience such as military or teaching backgrounds (Table 5.2) associated positively with implementation. The following sections describe how transience of staff and players at clubs affected implementation.

Transience of staff

Where delivery-agents had at least 3 years experience coaching at their club, clubs adopted a top-down social hierarchy where players participated in the programme on request of the delivery-agent. The sole exception was where the delivery-agent was a player. In this instance the coaching staff delegated the delivery-agent [the player] the role. Conversely, where delivery-agents experience at a club was less than 2 years, the hierarchy reversed whereby the players influenced the participation of the club, in this instance negatively with respect to implementation, linking back to lack of shared vision. Lack of shared vision lead to dropout of one club, and was a barrier to implementation at another:

> *"The idea of me [a new coach] coming in and saying right, we're now going to do [gives example exercises from programme] … a few of them saw that as hard work rather than part of a warm-up..." (Control club)*

Three clubs dropped out of participation due to transience of club staff. At two clubs the delivery-agent left the club, ending the club's participation. At another, the arrival of a senior club member influenced the club's participation in the pilot study, again ending the club's participation:

> *"… I've got [a new director of rugby] on board now and he didn't think it was … it was taking up too much time. And in hindsight I think it was wrong… I think we should have … carried on with the warm-up" (Intervention club)*

Transience of players

Transience of players led to organisational difficulties for delivery-agents and was a barrier to implementation. Players' irregular attendance at training was a barrier to warm-up implementation. Due to transience of players, specifically adhoc/intermittent player attendance, the warm-ups became laborious for clubs, often taking longer than the prescribed 15-minute duration to complete and disrupting the objectives of delivery-agents' training plans:

> *"...you get a different … core of sort of 20 of those [players] are here sort of eight sessions out of ten and the others aren't … if it was just that group of 20 that know what they're doing it's great and you can crack on with it but with the group that don't you've then got to try to integrate them and explain to them what each thing is, so that slows it down" (Intervention club)*

Leadership

The organisation context differed between clubs, however where strong leadership was evident it was a facilitator to implementation. Leaders at clubs displayed enthusiasm for and drive to complete the programmes which facilitated implementation:

> *"one of the things that's worked really well with this is… they've [the delivery-agents] brought enthusiasm into it and they've driven it. And again going back to that routine, the players have got used to them delivering it, their voices, the way they deliver it, so there's a structure, so they understand it" (Intervention club)*

Leadership was a quality at player level too; at one club the players assumed the role of programme champions:

> *"..the boys tended to not be interested in it [the warm-up] …they would see it as right, I'm the coach therefore it's part of my job description to do it. …before Christmas a few of the boys then took it on board that right, they now need to start*

doing things and they will lead the warm-up … and it sort of leaves me to take a step back really which has been nice" (Control club)

5.3.4 Programme-related factors

Programme tools

Programme tools were seen as a facilitator to intervention implementation. All teams reported that programme tools were clear and easy to understand and that this facilitated programme delivery by the delivery-agents. Delivery-agents reported the laminated cards were their preferred programme tool:

> *"These [referring to the laminated cards] are just a very simple tool that because they're laminated I can take out, get them muddy, wipe them down, regardless of the weather and you don't necessarily have to worry about it" – (Control club)*

No delivery-agent used the guidance manuals and one delivery-agent reported using the online videos. Despite only one delivery-agent using the online videos, 5 delivery-agents suggested the videos were a beneficial adjunct, which would provide clarity on how to perform exercises, should the laminated cards not have been clear enough.

Granted the opportunity to suggest changes to the materials, no suggestions were made regarding the layout of exercises on the laminated cards or in the manual with respect to improving clarity of instructions to benefit delivery-agents' understanding. Suggestions for future improvement in the training materials included; to produce a small exercise booklet or 'pocket guide' containing the same information as the laminated cards, while one other club suggested electronic materials that could be viewed through a mobile phone or tablet, which may be distributed to players.

Programme delivery

Adequate training of the delivery-agents was a facilitator to intervention implementation. All delivery-agents reported the programme training they received from the research team was sufficient for them to deliver their allocated programme during the season whereby no suggestions for improvement were made. Following training delivery-agents reported high self-efficacy and suggested that they'd developed adequate skill proficiency following the training to conduct the warm-up within their club:

"I think you've delivered more than what I was actually expecting… it's made us feel that actually we're playing a part in something that could really affect the game in the future ... Your team have come in this, given us information, given us developments [referring to phase progressions]… you ran that first session yourself. We watched, saw, got a feel for it. I don't think anything would have been added by more training from you to us" (Intervention club)

Continuity of exercises

Similarity between exercises from one phase to the next phase was predominantly seen as a facilitator. Progressions offered players sufficient challenge to maintain their interest, while importantly the exercise progressions had enough similarity to the current warm-up exercises that delivery-agents didn't feel overwhelmed when introducing them:

"there's still a common theme through it, the players are really sort of understanding it. The times of changing have come probably just at the right time" (Intervention club)

Phase duration

The 6-week phased design of the interventions was suggested to be ideal for community rugby by half of all delivery-agents interviewed. The 6-week duration permitted players to gain exposure to the programme despite their intermittent attendance. The 6-week duration facilitated self-efficacy of both players performing the exercises and delivery-agents in conducting the programme:

"when phase 2 turned up you felt that they [the players] were just about tired of Phase 1, a change is as good as a rest as much anything else. And you could see the progression, you could see how you got from there to there, from there to there…" (Intervention club)

Movement based exercises

Linked closely to poor weather conditions, movement based exercises, i.e., exercises requiring players to move in space, were considered as a facilitator to implementation. In contrast, static exercises, those not requiring players' movement in space, were a barrier.

" I think there's no doubt about the value of doing those exercises or why they're being done but the whole thing slows down" (Intervention club)

"they're getting cold… like the other week it was like freezing cold and it's like they were stood around … ran around and got warmed-up and then you're just standing like that trying to resist in terms of doing …'whatever it was exercise' and it's just like bloody freezing" (Control club)

Eccentric shoulder exercises

Eccentric shoulder exercises formed part of the intervention warm-up. All treatment clubs perceived these exercises as a barrier to implementation. Eccentric shoulder exercises were ground based, interlinking with the previous two barriers (poor weather and being ground based), and didn't involve players moving in space, which was a facilitator. The eccentric shoulder exercises were too difficult for players to understand how to perform from the delivery-agents' instruction. Delivery-agents all adapted this exercise, swapping them for an isometric shoulder exercise they considered better received by players, though demonstrating a lack of understanding of the rationale behind the exercises.

"we all were like well why are being laid on the floor because we could do it standing" (Intervention club)

"they [the players] preferred the … where the shoulder exercises become a static exercise pushing against resistance but not moving, they felt those were much better and I think we felt those were much better as well" (Intervention club)

5.3.5 Environmental

Cold and / or wet weather

Poor weather, specifically cold and wet conditions, was a highly distinguishing theme whereby poor weather was a barrier to implementation. Eleven (85%) of the thirteen delivery-agents interviewed indicated that poor weather was a catalyst for programme-related barriers including ground-based exercises, movement based exercises and programme duration as described in the previous sections.

"lying on the floor in soaking wet mud, you don't want to be doing that before training, you want to try and keep moving, do you know what I mean, so there's a lot of static stuff on there" (Intervention club)

"you can have some nights where it's absolutely carnage out there with mud,

there's not a lot of grass on some of them. So if it rains a lot you get a lot of issues there. So trying to do a bunny hop or stuff on the floor, it's just crap" (Control club)

5.4 Discussion

This study explored factors that influenced successful implementation of two rugby warm-up programmes during an injury prevention pilot study in men's community rugby union. Insights into the interplay of factors that impacted on clubs' abilities to successfully implement the warm-up programmes were gained from 14 delivery-agent interviews.

Delivery-agents from all clubs reported that both warm-up programme training (86%) and programme tools (86%) such as laminated exercise cards, facilitated implementation of warm-ups at their clubs due to providing delivery-agents with high self-efficacy (86%). Other highly distinguishing implementation facilitators included warm-up progressions being scheduled every 6 weeks (50%), which helped reduce exercise stagnation for the players, and similarity in exercises between phases (43%), which encouraged an easy transition from one phase to the next. In contrast, delivery-agents from all clubs highlighted that ground based exercises (86%) provided the greatest barrier to implementation, though this was largely influenced by poor weather conditions (86%), as ground based exercises exposed players to laying on cold muddy pitches. Also related to cold and wet weather, the delivery-agents recommended more movement based exercises (43%) to be included as movement based rather than static exercises were perceived as distracting players' attention from the cold English weather.

All delivery-agents reported that their programme training and the programme tools (i.e., laminated cards and manuals) gave them the confidence and skill proficiency to delivery the programmes as required within their clubs, which resulted in high self-efficacy. As coaches can have a large effect on player behaviour (Twomey et al., 2009) each club received their own training session led by one of the researchers in order to maximise coaches' exposure to the programme, including programme rationale, materials and data reporting. A coach-focussed delivery of materials has been shown to be more effective than providing materials alone, leading to greater programme adherence (Steffen et al., 2013). Warm-up training included an initial introduction of the warm-up's exercises and progressions to the club's coaches. This introduction provided an opportunity to educate coaches on how to accurately translate the programme to players (McKay et al., 2014), such as basic justification for exercises used. A full demonstration of the first phase of the club's warm-up was given to all attending players, led by the visiting researcher. This demonstrated to coaches how the warm-up could run and provided coaches the opportunity to facilitate the session under supervision of the research team. During the warm-up the researcher also gave justification for the exercises to the players. For example, this was done by the researchers suggesting how warm-up exercises may act to prevent common rugby injuries. This introduction to the exercises educated players by providing some basic underpinning theory from prevention research in order to make players aware of the potential benefits for them and in doing so it facilitated their acceptance of the programme (O'Brien and Finch, 2016). The justification of exercises to the players by the research team member also demonstrated to the coaches of how to translate the club's programme to players in practice. Following the demonstration, coaches were offered further time for any questions they had to be answered. As the delivery-agents all displayed having high self-efficacy following this delivery approach, a similar approach should be considered for future intervention training.

Despite agreement between delivery-agents regarding the adequacy of programme training, delivery-agents recognised that programme acceptance or non-acceptance by key players', such as the club captain who may have significant influence over his peers, affected implementation. Where key players had 'bought-into' a programme, these players motivated their peers and facilitated implementation. During mid-season at one club, key players assumed the role of delivery-agent, taking the responsibility away from the coach, which again facilitated implementation. Conversely, at another club, despite the enthusiasm of coaching staff regarding programme implementation, the research team were made aware that key players' non-acceptance of the programme led directly to their club's early drop out of the study. This club declined to be interviewed. These examples highlight the influence key players can have on implementation. To maximise implementation success, key players should be nominated as 'programme champions' and facilitate programme implementation (Stith et al., 2006; Durlak and DuPre, 2008; Donaldson and Finch, 2013). In the current study, where key players and delivery-agents shared the same vision, i.e., the extent to which players and coaches were united regarding the value and purpose of the programme (Durlak and DuPre, 2008), clubs had improved programme buy-in from their players. Delivery-agents from these clubs reported numerous benefits including improvements in team focus, morale and in their players' movement competency. In future studies recruitment and training should target key players at each club (recruited by the delivery-agents) to assume the role of 'programme champion' and promote a shared vision within the club.

Poor weather was a barrier to warm-up implementation for all clubs. The effect of poor weather was exacerbated by a number of exercises being static (i.e., not requiring players moving from one place to another), being ground-based, or both. A number of these exercises were frequently programmed in series, further compounding weather related barriers. Weather has been reported as a barrier to implementation in studies from other countries too. In Canada, inclement weather caused training sessions to be cancelled during a FIFA 11+ effectiveness trial (Steffen et al., 2013) reducing players' programme exposure. In Australia, wet weather led to poor ground conditions and players to wear studded boots, giving rise to difficulties in using equipment such as mini-trampolines which would either sink into the mud or be damaged by studded boots during the preventing Australian football injuries with exercise (PAFIX) programme trial (Twomey et al., 2015), reducing programme fidelity (i.e., exercises not being completed as prescribed). To maximise the potential for implementation during times of poor English weather the combinations of static and ground based exercises require further consideration before inclusion in a large-scale trial. Static exercises may need better integration with non-static exercises, or where exercises are both ground based and static, these may need replacing. In such instances a more 'weather appropriate' exercise that would achieve the same theoretical benefit should be used as it is important not to reduce the intended benefit of the warm-ups. This may facilitate implementation though increased player acceptance of the exercises.

The eccentric shoulder strength exercises were only included in the intervention warm-up and are a prime example of a static, ground based exercise, and an exercise that all intervention clubs suggested should be removed from the programme. The eccentric shoulder exercises took approximately 4 minutes to complete, requiring a large proportion of the 15 minutes allocated for the full intervention. During club visits by the research team, players displayed low self-efficacy practicing the eccentric shoulder exercises with players (and delivery-agents) instead resorting to upright, static shoulder strengthening exercises from a different phase of the programme. As well as being a programme specific barrier, the eccentric shoulder exercises may have been a catalyst for two other barriers, one being poor peer understanding of exercises reported by 40% of intervention delivery-agents (from 4 of 5 intervention clubs) and was likely reflected in the low self-efficacy observed during visits by the research team. The second barrier was the need for more movement based exercises, reported by 60% of delivery agents (all intervention clubs). These two barriers were unique to the intervention arm. As a response, alternative approaches are needed for the shoulder which might include use of isometric shoulder exercises throughout the programme. The implications of swapping eccentric shoulder exercise with static shoulder exercises are unknown as the efficacy of either type of shoulder exercises for acute shoulder injury risk reduction is unknown (Steffen et al., 2010). In theory, replacing eccentric shoulder exercises with static shoulder exercises could negatively affect shoulder strength gains and could be less efficacious for injury prevention. However, the intolerance of the eccentric shoulder exercises by players suggests that if included in a programme, eccentric shoulder exercises would not be effective. In contrast static exercises may improve programme effectiveness as these were better received by players, so should result in better adherence in the long term.

The time taken to complete exercise programmes has been recognised as a barrier to implementation at player (Engebretsen et al., 2008; Cumps et al., 2008), team (Petersen et al., 2011) and coach (Petersen et al., 2011; Soligard et al., 2010) levels. The warm-ups provided to participating clubs in this study were designed to last 15 minutes. When delivery-agents were questioned regarding how long the warm-ups took to complete, the typical response was 15 minutes. Fifteen minutes was also the duration delivery-agents suggested would be acceptable for a warm-up. Despite the time taken to complete the warm-ups and the suggested time a warm up should take both being 15 minutes, approximately half of delivery-agents from both trial arms suggested the warm-ups they were provided needed to be shortened. Possible causes for programme duration feedback within the intervention arm may relate to the nature of movement control exercises. Movement control exercises require greater focus on an individual's own movement patterns, often being performed relatively slowly in a controlled fashion. This focus may feel drawn out, especially during static exercises, or when exercises involved lying on a wet muddy floor. However, delivery-agents from the control arm provided similar feedback, despite having a programme consisting of active, non-ground based exercises. A potential explanation, based on observations from research team visits to clubs, is most clubs played touch rugby, often for longer than 30 minutes before implementing their warm-up programme. This was often due to poor player punctuality, which itself has been reported as a barrier to implementation (Finch et al., 2014; Twomey et al., 2015). As clubs often trained for just 90 minutes per session, following 15 minutes of programme delivery only 45 minutes remain for clubs to complete their session plans. Unfortunately, due to community rugby reflecting the social side of rugby where players often travel from work and between other commitments, a solution is lacking, though clubs should be recommended to start the programme promptly as not to erode their own session time.

Following the results of this pilot study the following recommendations require consideration before conducting a large scale randomised controlled trial. Due to facilitating implementation, a similar club specific delivery is advised, whereby delivery-agents are introduced to the programme materials before offered a demonstration of the exercises. Delivery-agents should be given feedback on their delivery of the exercises to their players during this initial visit to re-enforce and promote delivery-agents' self-efficacy. During club's initial programme training multiple club members that may act as delivery-agents during the season should be trained due to the negative impact of transience of staff, which is common within community club settings. Clubs should select their own programme champions, who should attend and receive specific programme training to help facilitate players' acceptance of the programme. The format of materials particularly the inclusion of laminated programme cards that detail the exercises including relevant key points of the exercise should be maintained. While both the 6-weekly phase and similarity of exercises between phases should be continued, the exercises included require revision. Where possible ground based exercises should be minimised, avoiding exercises that require players to sit or lay on the floor. This is particularly important for phases 3 onwards that cover the winter period where English weather is particularly poor. Exercises may also require re-organisation to alternate between exercises requiring players moving in space and exercises that are static. Within the intervention programme, inclusion of eccentric shoulder exercises needs careful consideration, with a possible option being to maintain static resistance exercises throughout each phase, as isometric shoulder exercises may still offer strength benefits and were better received by the players, facilitating implementation.

5.4.1 Strengths of the study

Use of semi-structured interviews facilitated participants' open responses to topics providing rich insights into the interplay of factors that impacted on clubs' delivery of their warm-up programme. The study was conducted approximately two thirds of the way through the regular season, enabling participants to consider issues relating to their experiences of programme implementation. The timing of interviews within the season allowed delivery-agents time to reflect on and observe intermediate outcomes of the programmes. While this study was restricted to a small sample of rugby clubs, reflecting the nature of a pilot study, there is little reason to think the factors identified would differ to those experienced in clubs elsewhere in England.

5.4.2 Limitations of the study

Participants were recruited from clubs in a restricted geographical area coinciding with participation criteria and limitations of the pilot study. Delivery-agents who participated were either contacted directly or nominated by other club delegates. While factors influencing programme implementation were obtained, delivery-agents from just two dropout clubs were interviewed. As such pertinent information relating to barriers to programme implementation may not have been captured due to this bias. Rationale for dropout at dropout clubs was summarised from field notes made during the pilot study and may not adequately reflect the clubs' situations and this should be considered when interpreting the results of this study. Interview participants did not include the players as the end users of the programme. For example players motivation and perceived value of injury prevention may require consideration before effective programme implementation can be conducted as part of a national injury prevention strategy in men's community rugby.

5.4.3 Conclusion

This research has enhanced the understanding of factors affecting the translation of injury prevention research into practice within a men's community rugby population. The community rugby environment provides a challenging implementation environment that requires a constructive and adaptable approach. However, the challenge now is to address these factors, to utilise the facilitators and adapt to the barriers. These factors need incorporating into the (re)design stage during further development of this area of injury prevention research.

CHAPTER SIX

EFFICACY OF AN INJURY PREVENTION EXERCISE PROGRAMME IN ADULT COMMUNITY RUGBY UNION: A CLUSTER RANDOMISED CONTROL TRIAL

6.1 Introduction

Sports injuries negatively influence team success (Hägglund et al., 2013b; Williams et al., 2015) and may lead to withdrawal from sports participation (RFU, 2011; Grimmer et al., 2000). Injuries are also associated with secondary degenerative disease including osteoarthritis (Maffulli et al., 2010; Lohmander et al., 2004) which can impact on long-term quality of life (Salaffi et al., 2005). There has not been a large scale movement control injury prevention randomised controlled trial in men's community rugby union, despite a need to minimise injury rates to maximise sports participation and maintain players' long-term health.

Exercise based injury prevention interventions including the FIFA 11+ (Soligard et al., 2008) focus on reducing lower-limb injuries by means of exercises targeting balance, co-ordination, strength and power. In soccer, the FIFA 11+ has been reported to reduce injury incidence rates by between 32% (Steffen et al., 2013) and 72% (Grooms et al., 2013). However, in addition to the common injury mechanisms in soccer, rugby union (rugby) has additional contact/collision events. In community rugby, 80% of match injuries were associated with contact events (Roberts et al., 2013) compared with 44% in community soccer (McNoe and Chalmers, 2010). The high-impact collision nature of the rugby tackle (Hendricks et al., 2014) can result in blunt force trauma injuries. For example, fractures and lacerations account for 27% of all head injuries (Roberts et al., 2016). Similarly, acromio-clavicular joint dislocation is the most common rugby shoulder injury (Headey et al., 2007), where the injury mechanism is commonly direct impact of the player's shoulder with the floor during a tackle (Crichton et al., 2012). Such injuries are likely difficult to prevent through movement control programmes.

Knee and ankle ligament injuries combined with hamstring injuries account for 33% of injuries overall and are the most common non-contact rugby injury diagnoses (Roberts et al., 2013). Importantly, injury prevention programmes have reduced knee (70% reduction) and ankle sprains (62% reduction) (LaBella et al., 2011) as well as hamstring strains (70%

reduction) (Petersen et al., 2011). Although the FIFA 11+ was designed to reduce lower-limb injuries in soccer, implementing the programme in basketball reduced lower-limb injury 32% (Longo et al., 2012). This indicates that the type of exercises included in the FIFA 11+ may be appropriate across sports where lower-limb injuries predominate. Lower-limb injuries are common in rugby, but upper-limb and head and neck injuries account for 41% of all injuries (Roberts et al., 2013) compared with 6% in soccer (Falese et al., 2016). The profile of injuries in community rugby therefore warrants a new movement control exercise programme.

The aim of this study was to investigate the efficacy of a rugby specific movement control injury prevention programme to reduce injury burden in men's community rugby union players. It was anticipated that intervention clubs would have a reduced injury burden compared to control clubs following programme implementation.

6.2 Methods

6.2.1 Trial design and randomisation:

This prospective cluster randomised control trial was designed in accordance with the CONSORT framework for cluster-randomised trials (Campbell et al., 2012). The playing population from which the study sample was recruited has been described previously as Semi-professional (Rugby Football Union (RFU) levels 3-4; highest level of English community rugby), Amateur (RFU levels 5-6) and Recreational (RFU levels 7-9) (Roberts et al., 2013). Injury incidence varies across these playing categories (Roberts et al., 2013) and therefore recruited clubs were stratified by playing level before being randomly allocated to the intervention or control group.

6.2.2 Ethical approval

The study was approved by the Research Ethics Approval Committee for Health (REACH), University of Bath, UK (Reference: EP 14/15 142).

6.2.3 Sample size

The sample size was estimated (Hayes and Bennett, 1999) at 54 clubs (27 clubs per trial-arm, intervention/control) for a minimally important (α = 0.05) injury burden rate ratio of 0.70 or less based on expected injury burden of 899 days/1000 player match-hours (Roberts et al., 2013) in the control group. This allowed for an anticipated 50% drop-out rate and was adjusted for cluster coefficient (k = 0.26) (Roberts et al., 2013) and exposure of 480 player match-hours per club (cluster). Sample size was calculated at the club level due to inadequate data reporting at the player level during the pilot study, and due to data used to calculate the cluster co-efficient having been reported at the club level also (Roberts et al., 2013).

6.2.4 Study setting and recruitment

Between March and June 2015, before the 2015/2016 pre-season, 856 men's community rugby clubs competing in RFU league levels 3-9 in England were invited to participate in this study (Figure 6.1). Inclusion criteria were that clubs must have access to a registered healthcare practitioner for injury diagnoses (Sports Therapists, Osteopaths, Chiropractors, Physiotherapists or Physicians).

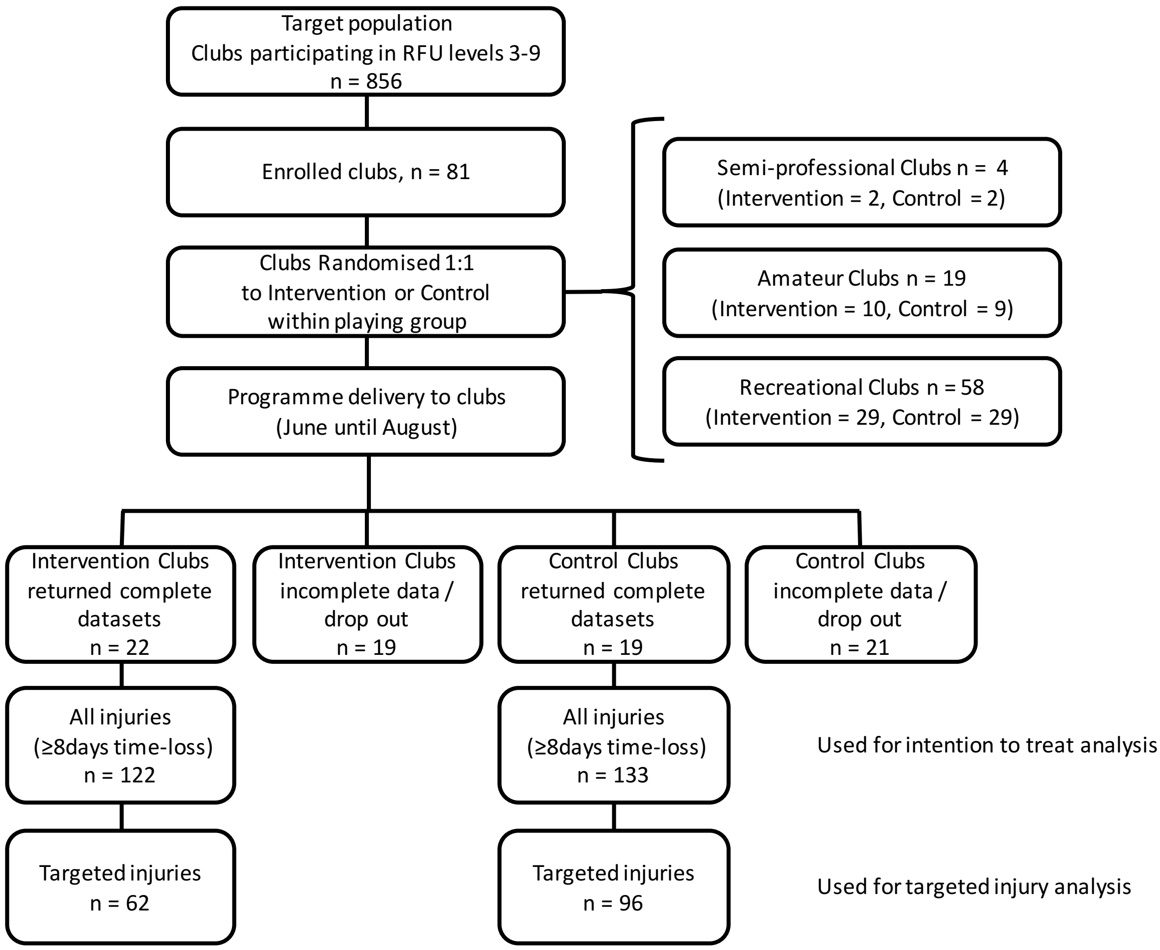

Figure 6.1. Flow chart of clubs through study period.

6.2.5 Programme Design

Before the 2014/2015 pre-season, a review of successful injury prevention exercises from different sports settings was conducted alongside a review of men's community rugby injury epidemiology (Chapter 2). An evidence-informed injury prevention exercise programme reflecting the injury profile of community rugby players was developed following discussion with an expert group of scientists and practitioners in sports medicine that specialised in human movement, injury prevention, epidemiology and rehabilitation (Chapter 4). The intervention programme included proprioceptive, mobility and strengthening exercises within a progressive structure targeting the lower-limb, shoulder, head & neck. The control programme included dynamic stretching, and non-targeted resistance exercises presented in a similar progressive format to the intervention. A pilot-trial was conducted during the 2014-2015 season in 16 clubs. Delivery-agents (typically coaches) from pilot study clubs were interviewed to determine factors that affected implementation, following which the exercise programmes were modified (Chapter 5). Revised programmes were examined by a second expert group of strength and conditioning coaches and sports physiotherapists (Chapter 4).

6.2.6 Exercise programmes

The final exercise programmes included seven 6-week, progressive designs spanning the 2015/2016 rugby pre-season and in-season period to be used at training sessions (twice weekly) and pre-match (once weekly). Programmes recommended 5-10 minutes of small-sided games after which the main content lasted 15 minutes. The control programme followed a raise, activate, mobilise and potentiate format (Jeffreys, 2006) incorporating whole-body dynamic stretching and resistance exercises, such as partner grappling, front-planks, press-ups and sprint drills, before finishing with high intensity running exercises (Appendix *O*). The intervention focused on proprioception, balance, cutting, landing, and resistance exercises including bounding exercises and Nordic-curls. The intervention finished with the same high intensity running exercises as the control programme (Appendix P).

6.2.7 Blinding of clubs

Club members were blind to which programme they received. Clubs were informed they were involved in a study evaluating the efficacy of different combinations of exercises for injury risk reduction and that clubs throughout the country were using different exercise combinations. This was deemed a pragmatic approach to limit contamination due to clubs who, due to being randomly assigned, could be situated in close geographical proximity to other participating clubs.

6.2.8 Programme delivery

Each club was visited by a 'programme trainer' from the research group to train each club's nominated 'delivery agent' (commonly the strength and conditioning coach) in how to deliver the programme to their players. Seventy four percent of clubs (n = 60) received training before the start of pre-season and 26% (n = 21) received training before the start of the competitive season. Two clubs received training under 5 weeks before the start of the season.

6.2.9 Data collection

Data were collected during the 2015-2016 English rugby union rugby season from July 2015 until May 2016. Clubs nominated a programme co-ordinator to report 1st team match exposure, exercise programme compliance and match injuries on a weekly basis using standardised forms. Data collection forms were available in paper and electronic formats.

6.2.10 Injury definitions

First team match injuries that resulted in absence from match play for ≥8 days was defined as a 'time-loss' injury. Injuries were recorded using the Orchard Sports Injury Classification System (version 8: Rae et al., 2005) detailing injury type and location. The date a player was fit to play was recorded as the return to play date. Overall injury incidence refers to injuries with a ≥8 days time-loss. Severe injuries were defined as injuries with >28 days time-loss (Fuller et al., 2007a). Injury burden was defined as the total number of days lost from training or match-play. Targeted injuries were defined as injuries to the lower-limb (buttock, hip, upper-leg, knee, lower-leg, ankle & foot), head and neck, or shoulder (glenohumoral joint), with diagnoses limited to muscle strains, ligamentous sprains, joint and neurological injury that resulted in ≥8 days time-loss. Diagnoses including haematoma, laceration/contusion, fracture and undiagnosed pain at any body site were excluded from the targeted injury analysis (Appendix Q).

6.2.11 Outcomes

Injury burden was the primary outcome between trial arms for all injuries. Secondary outcomes included overall injury incidence, targeted injury incidence, and targeted injury burden.

6.2.12 Statistical methods

Data analysis, computed using SPSS (Version 22 for Windows, Armonk, NY. IMB Corp), was performed on an intention to treat (last observation carried forward) basis with the control clubs as the reference group.

Injury burden (number of days absence per 1000 player match-hours) and 90% confidence intervals (CI) and injury incidence (number of injuries per 1000 player match-hours) were estimated vis-à-vis for primary and secondary outcome measures of this study. Intention to treat analyses were performed, where the General Estimating Equation was used to conduct Poisson regression analysis and explore the effects of the intervention on injury outcomes. Club (cluster) and playing level (semi-professional; amateur; recreational) were included as random effects, and analysis was offset for club match-exposure. Due to zero inflation of data, a Chi Square adjustment was applied to the regression model. Club programme compliance was defined by two measures: overall club compliance (proportion of all possible sessions where the programme was delivered), and the number of club programme sessions/week. Overall compliance, adjusted for varying lengths of clubs' participation in the study and the proportion of compliant sessions, was measured as the number of compliant sessions/total potential compliant sessions. Results are presented as Rate Ratio (RR) with 90%CI and interpreted using Clinical-Magnitude Based Inferences (Hopkins and Batterham, 2016). Ten per cent was considered the minimum effect and threshold values for unlikely/harmful (25) and most/very unlikely (0.5) were used to derive the odds ratio for making clinical inference.

6.3 Results

6.3.1 Overview

Eighty-one clubs were randomised to the intervention (n = 41) or control (n = 40) arm of which forty clubs (intervention = 19, control = 21) dropped out or otherwise returned incomplete data. Forty-one clubs (intervention = 22, control = 19) returned complete data detailing 255 injuries averaging 5.5±5.7 injuries per intervention club and 7.0±5.1 injuries per control club. Total player match exposure was 19560 hours (intervention = 9900, control = 9660 player match-hours), averaging 477±121 player match-hours per club. Across the 41 clubs, 222 different players sustained ≥1 injury. All injuries were reported as acute injuries and the majority were associated with contact mechanisms (contact = 199 [78%], non-contact = 56 [22%]).

Overall injuries

Overall injury burden was 649 (90%CI = 640–659) days/1000 player match-hours where the incidence (≥8 days time-loss) for both trial arms combined was 13.0 (90% CI = 11.8–14.4) injuries/1000 player match-hours. There were 135 severe injuries (>28-days time-loss) with an incidence of 6.9 (90%CI = 6.0–7.9) injuries/1000 player match-hours. Intention to treat analysis indicated a 20% reduction in both overall injury burden (RR, 90%CI = 0.8, 0.5-1.4) and severe injury incidence (RR, 90%CI = 0.8, 0.6-1.3) and a 10% (RR, 90%CI = 0.9, 0.6-1.3) reduction in overall injury incidence for the intervention compared with control group, but these differences were unclear (Table 6.1 and Figure 6.2).

6.3.2 Targeted injuries

One hundred and fifty-eight injuries (62% of all injuries) across both trial arms met the ‘targeted injury’ definition with a burden of 448 (90%CI = 440-456) days/1000 player match-hours and an incidence of 8.1 (90%CI = 7.1-9.2) injuries/1000 player match-hours. There were 89 severe targeted injuries with an incidence of 4.6 (90%CI = 3.8-5.4) injuries/1000 player match-hours. Poisson regression analysis indicated an unclear 40% (RR, 90%CI = 0.6, 0.3-1.3) reduction in targeted injury burden for the intervention group compared to the control group (Table 6.1 and Figure 6.2). A likely beneficial 40% (RR, 90%CI = 0.6, 0.4-1.0) reduction in both overall targeted injury incidence and severe targeted injury incidence (RR, 90%CI = 0.6, 0.3-1.0) was identified for the intervention compared with control group.

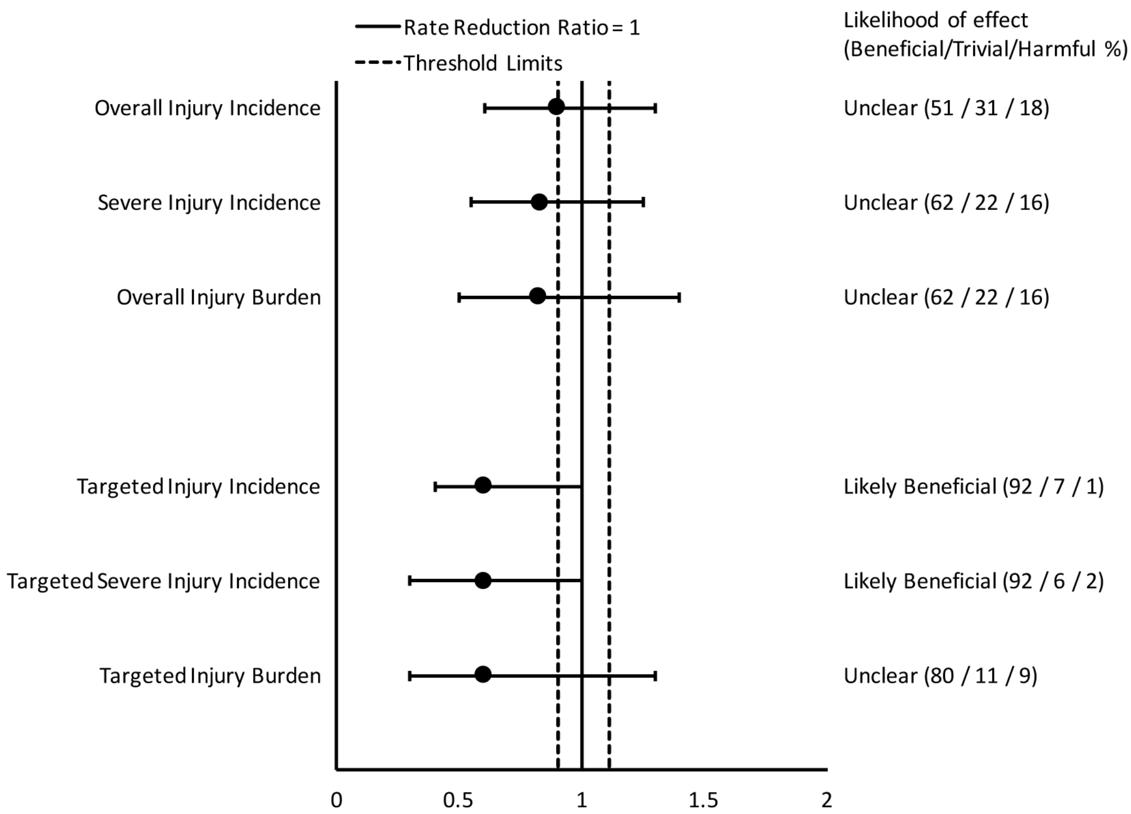

Figure 6.2. Rate reduction ratio (RR) and 90% confidence interval of overall and targetted injury outcomes for the intervention group based on Poisson regression analysis adjusted for cluster and playing level. Clinical inference (right column) indicates the likelihood of effect. Vertical dashed lines represent 10% minimum effect thresholds and the vertical solid line represents no effect compared to the control group.

Table 6.1. Incidence rate ratios by injury stratification (all injury, targeted injury) based Poisson regression analysis adjusted for cluster and playing level.

	Arm	Clubs (n)	Player match hours	Injuries/ Days lost Count	Rate per 1000 player match-hours (90% CI)	RR (90% CI)	Magnitude based inference (Beneficial/Trivial/Harmful) (%)
Overall Injury							
All Incidence	Control	19	9660	133	13.8 (11.9–15.9)	0.9	Unclear
	Intervention	22	9900	122	12.3 (10.6–14.3)	(0.60–1.3)	(51/31/18)
Severe Incidence	Control	19	9660	73	7.6 (6.2-9.2)	0.8	Unclear
	Intervention	22	9900	62	6.3 (5.1–7.7)	(0.55–1.3)	(63/25/12)
Injury Burden	Control	19	9660	6918	716 (702–730)	0.8	Unclear
	Intervention	22	9900	5783	584 (572–597)	(0.5–1.4)	(62/22/16)
Targeted Injury							
Injury Incidence	Control	19	9660	96	9.9 (9.7–10.2)	0.6	Likely Beneficial
	Intervention	22	9900	62	6.3 (5.1–7.7)	(0.4–1.0)	(92/7/1)
Severe Incidence	Control	19	9660	56	5.8 (4.7–7.2)	0.6	Likely Beneficial
	Intervention	22	9900	33	3.3 (2.5–4.4)	(0.3–1.0)	(92/6/2)
Injury Burden	Control	19	9660	5288	547 (463-648)	0.6	Unclear
	Intervention	22	9900	3472	351 (284-432)	(0.3–1.3)	(80/11/9)

6.3.3 Specific body locations

There was a likely beneficial 70% reduction in both burden (RR, 90%CI = 0.3, 0.2-0.7) and incidence (RR, 90%CI = 0.3, 0.2-0.6) of head and neck injury for the intervention group over control group (Table 6.2 and Figure 6.3). Forty-five of 48 'head and neck' injury diagnoses were concussion, and there was a likely beneficial 60% reduction in burden (RR, 90%CI = 0.4, 0.2-0.8) and incidence (RR, 90%CI = 0.4, 0.2-0.7) for this specific diagnosis in the intervention compared with the control group. Overall, twenty-seven injuries were reported for the shoulder (Table 6.2) where a possibly harmful 50% (RR, 90%CI = 1.5, 0.6-3.7) higher injury burden and likely harmful 70% (RR, 90%CI = 1.7, 0.7-3.8) higher injury incidence was found for the intervention group over control. There was an unclear 40% (RR, 90%CI = 0.6, 0.3-1.5) reduction in lower-limb injury burden but likely beneficial 40% (RR, 90%CI = 0.6, 0.4-1.0) reduction in lower-limb injury incidence for the intervention compared with the control group.

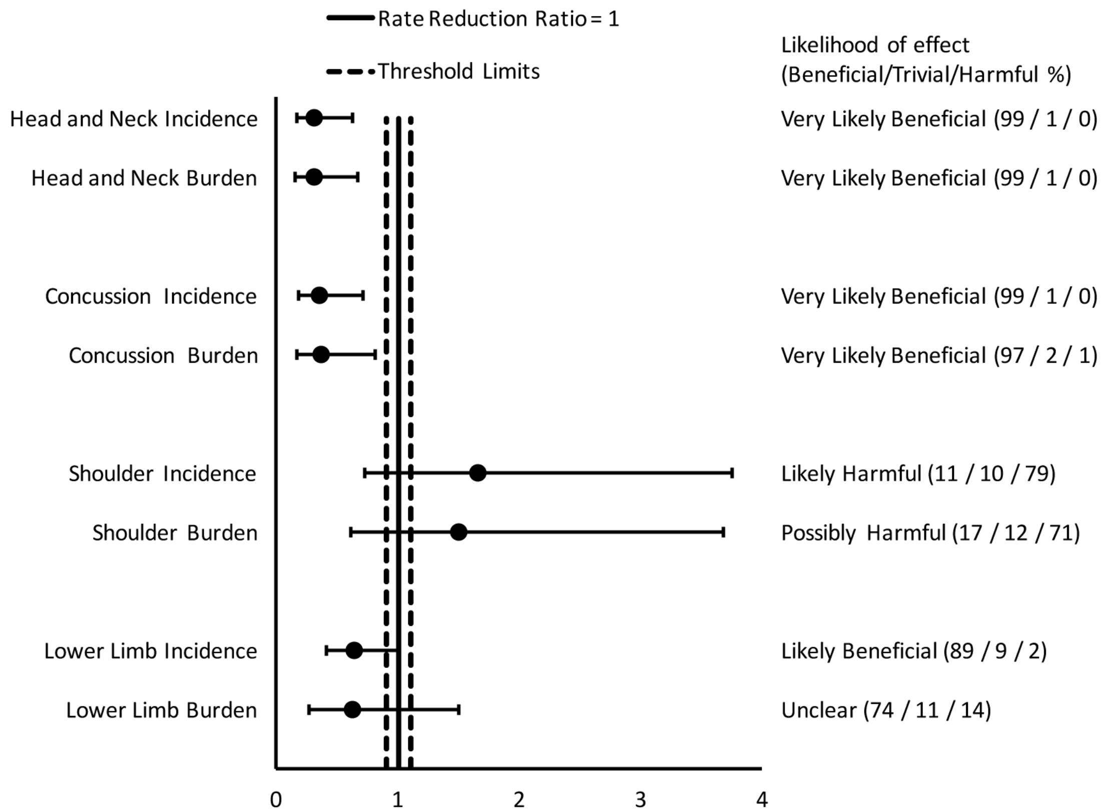

Figure 6.3. Rate reduction ratio (RR) and 90% confidence interval for targetted injury outcomes stratified by location for the intervention group based on Poisson regression analysis adjusted for cluster and playing level. Clinical inference (right column) indicates the likelihood of effect. Vertical dashed lines represent 10% minimum effect thresholds and the vertical solid line represents no effect compared to the control group.

Table 6.2. Incidence rate ratios for Targeted injuries, stratified by region (head and neck, shoulder and lower-limb) based Poisson regression analysis adjusted for cluster and playing level.

Target Injury and Arm	Clubs (n)	Player match hours	Injury Count	IIR (90% CI)	RR (90%CI)	Magnitude based inference (Beneficial/Trivial/Harmful) (%)
Head & Neck Incidence						
Control	19	9660	36	3.7 (2.8–4.9)	0.3 (0.2–0.7)	Very Likely Beneficial
Intervention	22	9900	12	1.2 (0.8–2.0)		(99 / 1 / 0)
Concussion Incidence						
Control	19	9660	33	3.4 (2.6-4.5)	0.4 (0.2–0.7)	Very Likely Beneficial
Intervention	22	9900	12	1.2 (0.9-1.6)		(99/1 /0)
Shoulder Incidence						
Control	19	9660	10	1 (0.6-1.7)	1.7 (0.7–3.8)	Likely Harmful
Intervention	22	9900	17	1.7 (1-2.9)		(11/10/79)
Lower-limb Incidence						
Control	19	9660	50	5.2 (4.1-6.6)	0.6 (0.4–1.0)	Likely Beneficial
Intervention	22	9900	33	3.3 (2.6-4.2)		(89/9/2)
Head & Neck Burden						
Control	19	9660	1164	120 (92-159)	0.3 (0.2 – 0.7)	Very Likely Beneficial
Intervention	22	9900	378	38 (24-61)		(99/1/0)
Concussion Burden						
Control	19	9660	983	102 (76-136)	0.4 (0.2 – 0.8)	Very Likely Beneficial
Intervention	22	9900	378	38 (24-61)		(97/2/1)
Shoulder Burden						
Control	19	9660	436	45 (27-76)	1.5 (0.6 – 3.7)	Possibly Harmful
Intervention	22	9900	673	68 (46-101)		(17/11/71)
Lower-limb Burden						
Control	19	9660	3688	382 (302-482)	0.6 (0.3 – 1.5)	Unclear
Intervention	22	9900	2421	245 (183-326)		(75/11/14)

6.3.4 Programme compliance

Programme compliance was high and was similar in both intervention (2.1±0.7 sessions/week, median = 85%, interquartile range = 62-90) and control (2.2±0.6 sessions/week, median = 83%, interquartile range = 65-92) study arms. Four clubs (intervention n = 3, control n = 1) completed their programme less than once weekly, eight clubs (intervention n = 3, control n = 5) completed their programme at least once but less than twice weekly, and 29 clubs (intervention n = 16, control n = 13) completed their programme at least twice weekly.

For clubs that completed the exercise programmes at least once weekly (n = 37) an unclear 30% reduction in targeted injury burden (RR, 90%CI = 0.7, 0.3–2.0) and likely beneficial 40% reduction (RR = 0.6, 0.4–1.0) in targeted injury incidence and was found for the intervention compared with the control group.

Median compliance was used to divide clubs into higher (≥median) and lower (<median) compliance groups. Intervention clubs (n = 11) with higher compliance displayed a very likely beneficial 60% reduction in both targeted injury burden (RR, 90%CI = 0.4, 0.2-0.7) and targeted injury incidence (RR, 90%CI = 0.4, 0.2-0.8) compared with the control clubs with higher compliance (n = 9).

Within the intervention arm, comparison of clubs with higher compliance (n = 11) to lower compliance (n = 11) indicated a likely beneficial 50% reduction (RR, 90%CI = 0.5, 0.2-1.2) in targeted injury burden with an unclear 30% reduction (RR 90%CI = 0.7, 0.4-1.4) in targeted injury incidence for higher compliance clubs.

6.4 Discussion

This is the first cluster randomised controlled trial to evaluate the efficacy of an injury prevention exercise programme to reduce injuries in men's community rugby players. Although the intervention programme reduced injury burden and incidence of severe injury by 20% and overall injury incidence by 10% no clear differences were found using intention-to-treat analysis and established clinical inference thresholds. However, for injuries targeted by the intervention, overall injury incidence and severe injury incidence were both reduced by 40% in the intervention group compared with control, which were clear beneficial effects. Of particular note is that the intervention group benefited from a 60% reduction in concussion and a 40% reduction in lower-limb incidence compared with the control group.

6.4.1 Targeted injuries

Concussion was 60% lower for both incidence (1.2 vs 3.4 injuries/1000 player match-hours) and burden (38 vs 102 days/1000 player match-hours) in the intervention compared with the control group. This reduction is possibly a result of the isometric neck strengthening exercises included in every phase of the intervention programme. These exercises were included based on existing evidence that isometric neck exercises increase neck strength in male rugby players (Geary et al., 2014) and that higher neck strength is suggested to decrease head accelerations during rugby collision events associated with concussion (Dempsey et al., 2015). For amateur rugby, this finding is very encouraging as research has linked concussion sustained during players' playing careers to deficits in cognitive functioning in later life (Hume et al., 2016). Given the magnitude of the difference in concussion incidence between the intervention and control groups in this study, this is evidence to suggest that all adult community rugby players should engage in weekly neck strengthening exercises.

A likely beneficial reduction of 40% was found for targeted lower-limb injury incidence for the intervention group over control group (3.3 vs 5.2 injuries/1000 player match-hours). The intervention programme incorporated lower-limb balance, proprioception and movement control exercises similar in nature to exercises in the FIFA 11+ (Bizzini and Dvorak, 2015), indicating that this approach is also efficacious for reducing injury in rugby, despite the high proportion of contact-related injuries. Intention-to-treat analysis from a neuromuscular-control intervention study in community men's Australian Rules Football (Finch et al., 2015), another sport with a high level of physical person-to-person contact, displayed a likely beneficial 20% reduction (RR, 90%CI = 0.8, 0.6-1.0) in lower-limb injury incidence and a likely beneficial 50% reduction (RR, 90%CI = 0.5, 0.3-1.0) in knee injuries. Given that ~50% of all community rugby injuries are lower-limb injuries (Roberts et al., 2013), our findings support the completion of these lower-limb exercises as part of a warm-up before training and matches.

Shoulder injury incidence (1.7 vs 1.0 injuries/1000 player match-hours, respectively) and injury burden (68 vs 45 days /1000 player match-hours, respectively) was likely harmful for the intervention group over control. Despite the higher rate of shoulder injuries, the intervention group had fewer shoulder dislocations (1 vs 5 dislocations) albeit more muscle/tendon injuries (15 vs 4 injuries) over the control group. There is no obvious explanation for the higher injury rate in the intervention group but all shoulder injuries were contact injuries and therefore may be harder to reduce via conditioning exercises. As the study was not powered to detect the incidence or burden of shoulder injuries specifically, the outcome may be a statistical anomaly.

Compliance and injury risk

Clubs' compliance rates were high, reflected by median compliance of 85% for the intervention group and 83% for the control group, where on average clubs implemented the programmes at least two times per week. Between group comparison for clubs that completed the programme at least once per week during the season indicated a 40% reduction in targeted injury incidence for the intervention group over the control group. Across community rugby clubs, some clubs only have access to training facilities once per week. It is encouraging to find that these clubs can benefit from reduced injury incidence provided they implement the intervention each week. In soccer, higher FIFA 11+ compliance produced a very likely beneficial 35% reduction in injury rates compared to intermediate FIFA 11+ compliance (Soligard et al., 2008). In the present study comparison between intervention clubs with higher compliance to lower compliance (≥85% to <85% of possible sessions) indicated a likely beneficial 50% reduction in targeted injury burden. This indicates additional benefit can be achieved when the intervention is implemented in the majority of training sessions and before matches.

The control exercises reflected normal "good practice" for this level of rugby and consisted of dynamic stretching and non-targeted resistance exercises. Overall injury incidence in the control group was 13.8 (90%CI = 11.9–15.9) injuries/1000 player match-hours, which is 18% lower than the incidence previously reported for adult community rugby players (IIR, 90%CI = 16.9, 14.9–16.5) (Roberts et al., 2013). Control exercises may have offered better physical preparation for players than current "normal practice", which is supported by feedback from pilot study delivery-agents (unpublished data) who reported the control programme was an improvement on their normal practice. Results may indicate that there is a need to improve warm-up practices in this population.

6.4.2 Conclusion

This is the first cluster randomised controlled trial to examine the efficacy of a movement control injury prevention programme in men's community rugby players. The intervention programme demonstrated clear beneficial effects by reducing concussion incidence by 60% and lower-limb match injury incidence by 40% compared with control. Men's rugby players are advised to incorporate the intervention programme exercises prior to training and match play.

CHAPTER SEVEN

DISCUSSION

7.1 Discussion of main findings

The aim of this thesis was to determine means by which men's community rugby player's welfare may be improved through the determination of injury risk and intervening to reduce injuries. Four novel research questions were proposed in Chapter 1 to meet this aim, and those questions were addressed in Chapters 3 to 6 of this thesis. This Chapter will summarise the main research findings of the thesis and discuss the extent to which the proposed research questions have been addressed. This Chapter will highlight the degree to which these findings have produced an original and significant contribution to existing knowledge. The research aims were achieved through the following questions:

7.1.1 Is there an association between men's community rugby players' functional movement competency, as determined using the Functional Movement Screen™, and risk of injury?

The main findings of this study were that men's community rugby players that presented both pain and movement asymmetry during Functional Movement Screening were associated with 3.6 times the injury burden and 3.2 times the injury incidence of severe injury compared to players with no pain or asymmetry. Functional movement asymmetry was the greatest individual risk factor for injury for men's community rugby players. Players that demonstrated movement asymmetry during Functional Movement Screening were associated with 2.3 times the injury burden, and 2.3 times the incidence of severe injury. With respect to a 'cut-off' score, players with a FMS score ≥16 were associated with a very likely beneficial 60% lower injury burden compared to players scoring <16. Players with a score ≥16 were associated with a likely beneficial 50% reduction in severe injury incidence compared to players with FMS scores <16. Overall, the results of this study demonstrate that, when used as a pre-season screening tool, the Functional Movement Screen can identify men's community rugby players that have an increased risk of time-loss injury.

7.1.2 What stages are involved in the development of a movement control exercise programme to reduce injury in men's community rugby?

To develop the final injury prevention exercise programme nine different stages were conducted. (1) To facilitate the sustainability of this research, funding was obtained, without which this research was not possible. (2) A review of injury prevention research was conducted. As no randomised controlled trails investigating exercise as a means of injury prevention existed in men's community rugby, information was considered from sports including soccer, basketball, floorball, handball, basketball and Australian rules football. This review included studies performed across cohorts of varying age and sex. This process helped identify forms of exercise that were efficacious for injury prevention, for consideration when designing a rugby specific programme. (3) Experts in injury prevention were consulted for a sister project that focussed on injury prevention in youth rugby. The consensus of this steering group regarding types of exercise worth including in an injury prevention exercise programme for youth rugby players were shared within the Rugby Science at Bath research group. (4) A pilot injury prevention exercise programme was designed for men's community rugby. (5) A feasibility study was conducted in a sample of men's community rugby clubs to assess the suitability of the pilot programme for the context of men's community rugby. (6) Feedback was obtained from pilot study club delegates to help identify factors that effected implementation of exercise programmes in men's community rugby clubs. (7) The intervention programme was redesigned based on the analysis of delegate feedback. (8) A second expert panel consultation evaluated the updated intervention exercise programme where further changes were advised. (9) Final adjustments were then made to the intervention programme in preparation for a cluster randomised controlled trial. The nine stages of the development process outlined above demonstrates how the final intervention programme was informed by the best available evidence and refined for the context of men's community rugby. These processes are applicable to all sports environments where practitioners are considering development of injury prevention exercise programmes.

7.1.3 What influences the implementation of structured warm-up exercise programmes in men's community rugby?

In the context of men's community rugby personal, behavioural, programme specific and environmental factors influenced implementation of structured warm-up exercise programmes. Implementation facilitators included: a want to invest in player welfare, delivery-agent self-efficacy, good peer understanding, perceived benefits of a programme, positive club culture, strong leadership, team organisation, clear programme tools, programme delivery, and continuity of exercises across different phases of the programmes. The greatest barrier to implementation was poor English weather. Specifically wet and cold weather, negatively influenced players' willingness to complete ground based exercises, such as eccentric shoulder exercises. The injury prevention exercise programme was perceived as too long in duration. This perception was influenced by the static nature of the exercises included in the injury prevention warm-up. This study demonstrated that a complex interplay of factors influenced implementation of exercise warm-up programmes in men's community rugby clubs. Research involving the end user's perspective of an injury prevention exercise programme is recommended as a valuable process to aid translation of theory into applied practice.

7.1.4 What is the efficacy of a movement control injury prevention programme in men's community rugby?

Implementation of a movement control injury prevention warm-up in men's community rugby was efficacious for reducing injury risk. Both intervention and control warm-up programmes were well accepted, indicated by high median compliance (≥83% of all recommended sessions). Overall targeted injury incidence and severe injury incidence were reduced by 40% in the intervention group compared with the control group, which were clear beneficial effects. The intervention group benefited from a 60% reduction in concussion and a 40% reduction in lower-limb incidence compared with the control group. As well as reducing injury when compared to the control programme, clubs within the intervention arm with higher programme compliance (≥85% of all recommended sessions) demonstrated 50% reduction in targeted injury burden compared to intervention clubs with lower compliance (<85% of all recommended sessions). Men's rugby players are advised to incorporate the intervention programme exercises prior to training and match play.

7.1.5 Summary and practical implications

Chapter 3 investigated the association of FMS score and injury outcome in men's community rugby players. Results of the study demonstrated that men's community players risk of injury was associated with functional movement as determined within the Functional Movement Screen™. A review (Moran et al., 2017) of FMS literature concluded that of 24 studies that investigated FMS score and injury using prospective designs, the only 'strong' evidence supporting the use of FMS as an injury prediction tool was in military studies (Bushman et al., 2016; O'Connor et al., 2011), where the pooled relative risk of injury for participants scoring ≤14 on the FMs was 1.47 (95%CI = 1.22-1.77) compared to participants scoring >14. While this does not present a particularly substantial increase in risk, injuries during basic training of 22,000 recruits was estimated to cost $16.5 million annually due to training days lost due to injury within the 12-week basic training camp. On the assumption that following the screening, the military's medical teams can intervene, and reduce the risk back to 'normal', this could result in a saving of $5.3 million due to training days lost to injury. However, this theory is based on large assumptions, as the cost saving does not account for the cost of performing the functional movement screening of 22,000 recruits, or the cost and time necessary for their subsequent treatment, where the efficacy of treatment is also unknown. The apparent lack of 'predictive power' of functional movement screens and the total lack of intervention studies to test the effect of combined screening and intervention programme efficacy was recently highlighted (Bahr, 2016). Within the context of men's community rugby, the practical implications of Functional Movement Screening also needs consideration before a recommended for its use in practice can be made. The following section demonstrates a theoretical situation should the Functional Movement Screen™ be employed as a pre-season screening tool in a men's community rugby club: Men's community rugby clubs may have access to a single physiotherapist that provides medical support to a squad of thirty players. Assessment and treatment of players is limited to training nights, twice weekly, that last 90 minutes each. It takes 1 hour to screen 5 players using the FMS method described in Chapter 3, thus 6 hours to complete screening for the squad of 30 players. This equates to two weeks of the Physiotherapist's player contact time to screen all players using the FMS. In Chapter 3, movement asymmetry, pain and asymmetry, and an FMS score lower than 16 were the factors associated with harmful increases in injury risk. Only 18% of players scored 16 or above on the FMS and did not display pain or asymmetry. As such, 25 of the 30 players screened would be identified as having a harmful increased risk of injury. Each player would need at least one further physiotherapy assessment to determine the source of their 'dysfunction'. A standard physiotherapy assessment takes 30 minutes, requiring a further 9 weeks to perform a physiotherapy assessment of the 25 'at risk' players. Overall, using this simplified example (i.e., the assumption applied is that one physiotherapy follow-up assessment would be sufficient to determine the actual problem, despite the potential for multiple causes each requiring investigation, thus simplifying the mathematics) 11 weeks would be necessary to adequately screen and medically assess a squad of 30 players in a 'normal' club environment. Men's community rugby clubs regularly start pre-season training near the start of July. As such, the 11 weeks of assessment would not be complete until early into the competitive season, where the risk of injury is highest (Quarrie et al., 2001; Garraway and Macleod, 1995; Roberts et al., 2013) and yet the players 'at risk' of injury would still not have received sufficient/any treatment to have had their injury risk reduced.

Applying the injury rates from Chapter 3 to this situation, the overall injury incidence for players scoring 16 or above on the FMS and who did not display pain or asymmetry compared to all other players was 12.7 vs 17.8 injuries/1000 player match hours. For a club this equates to 6 vs 9 injuries per club season (based on a 25-match season), with an overall injury burden of 169 vs 358 days per club season. For clubs with ambitions of league success, this difference in burden may appeal given the associations between injury burden and team success (Williams et al., 2015; Hägglund et al., 2013b). However, what must still be considered, is that no study has demonstrated that the combination of screening and post screening intervention has any benefit regarding injury outcomes. As such, at this time, FMS screening is not recommended for practice in men's community rugby.

Following success of injury prevention exercise programmes in sports including soccer and basketball, an injury prevention programme was developed for men's community rugby (Chapter 4, Chapter 5). The approach adopted during Chapter 4 related to stage 3 of the 6 stage injury prevention model Translating Research into Injury Prevention Practice (Finch, 2006). At the time of conducting the study information pertaining to the development of a sports injury prevention exercise programme was sparse. The process was influenced by information applied to intervention development in the health field (Craig et al., 2008) and also from a descriptive summary of the process outlined for the development of PAFIX (Finch et al., 2010). For this series of studies a total of 9 processes were followed (Figure 4.1; Chapter 4), providing a clear guide to future research wishing to develop other sports specific movement control injury prevention interventions. What should not be underestimated by future researchers is the time necessary, nor the resources required to perform such research. To conduct this research, funding was sought from two sources, the Rugby Football Union and the Private Physiotherapy Education Fund, and both stakeholders required delivery of the research within a two year time period (mid 2014 – mid 2016). In contrast, the development of PAFIX was conducted over a 4-year cycle from 2006-2009 (Finch et al., 2009). The most frequently implemented programme, the FIFA 11+, was developed following collaboration of research groups that created the FIFA 11 (Junge et al., 2002) and the Santa Monica Prevent Injury Enhance Performance (PEP) programme (Mandelbaum et al., 2005; Gilchrist et al., 2008). Both the FIFA 11 and PEP were first implemented in 2000 (Junge et al., 2002; Mandelbaum et al., 2005), and it wasn't until 2006 that the FIFA 11+ was developed due to poor uptake of the FIFA 11 and PEP (Bizzini et al., 2013), indicating at least a 6 year process for the development of the FIFA 11+. This demonstrates that the timescales involved to develop efficacious movement control injury prevention programmes is significant.

Having recognised the lack of attention given to implementation issues related to evidence-based injury prevention strategies, two further models have been proposed (Padua et al., 2014; Donaldson et al., 2016b). In Figure 7.1 these models are summarised and aligned with the stages of TRIPP (Finch, 2006).

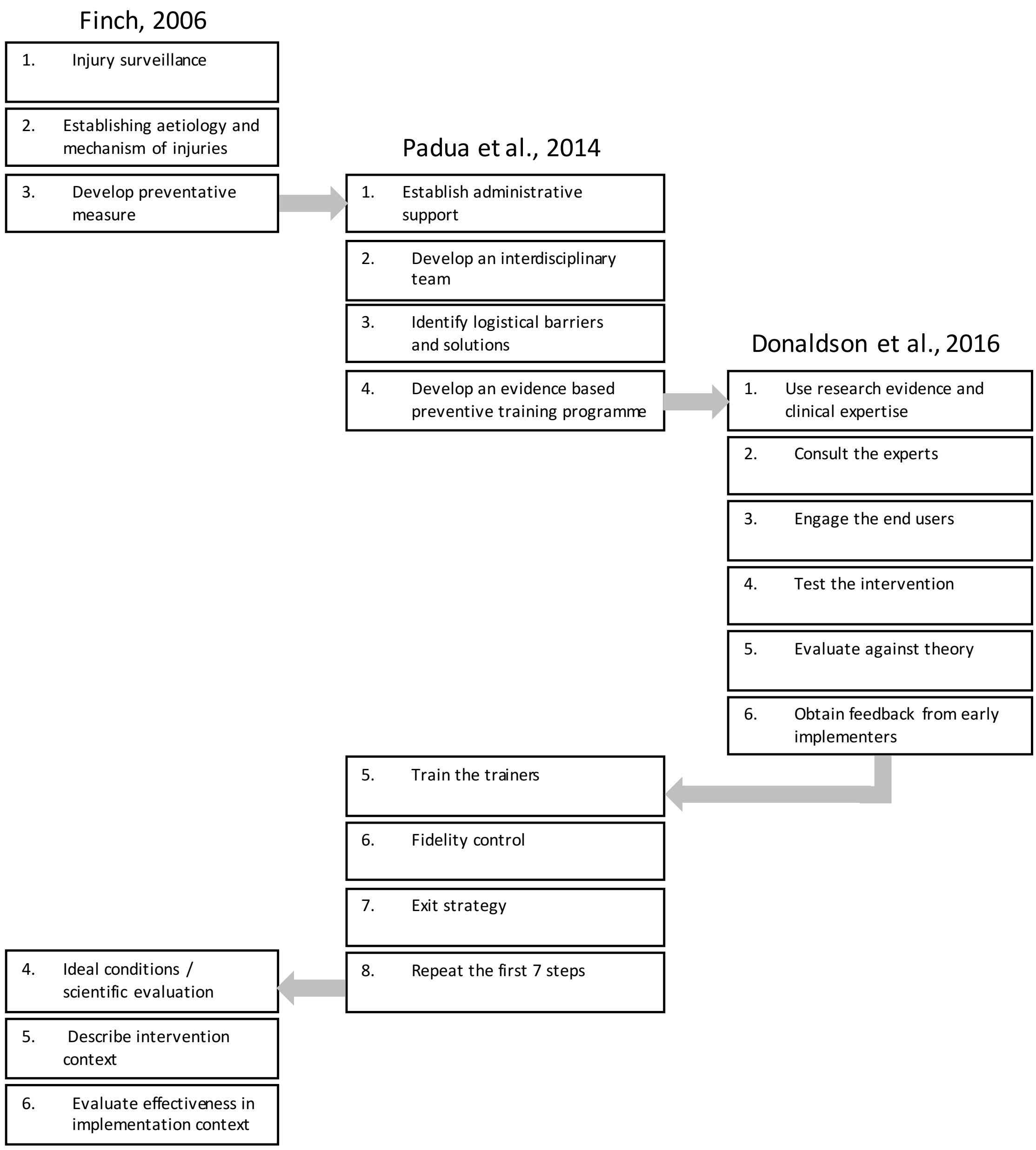

Figure 7.1 Comparison of stages proposed to guide the process of injury prevention in sport contexts

The stages conducted for the production of the final movement control injury prevention programme for men's community rugby closely resembles the stages and sequence of the process orientated approach outlined in Figure 7.1. This demonstrates that a robust and process orientated approach was used in the conduction of this series of studies. Chapter 5 of this thesis reflects step 6 of the model proposed by Donaldson et al. (2016b). Recognising that successful programme implementation influences programme outcomes (Gilchrist et al., 2008; van Beijsterveldt et al., 2012) feedback was obtained from early implementers (Donaldson et al., 2016). The main findings resulted in changes to the intervention programme exercises, such as reducing ground based activity and increasing the volume of exercises that involved movement of players in space, and that the materials (laminated cards and manual) and method of delivery (face to face) should be maintained.

Efficacy trials have demonstrated that injury rates are modifiable through movement control exercise interventions in sports where collisions are a rare occurrence and player to player contact should be avoided. Chapter 6 demonstrated that injury rates in rugby can be reduced despite its high impact contact nature. This is the first research that demonstrates a movement control programme can be efficacious at reducing injury in men's community rugby. However, the rate of shoulder injuries was higher in the intervention group. Due to the shoulder being a point of contact during the tackle, during a ruck and during mauls the shoulder is exposed to many potentially injurious events. Drawing focus to specific exercises, resisted rotation of the upper arm and protraction/retraction exercises targeted the rotator cuff and scapula stabilisers. As the prime stabilising musculature of the glenohumoral joint, in theory increased rotator cuff strength may have prevented shoulder dislocations. While strength was not measured during this research, the intervention group presented just one glenohumoral joint dislocation compared to five in the control group, though by contrast the intervention group had more muscle/tendon injuries about the shoulder region. As shoulder injuries represented just 22% of all injuries in the intervention arm, the injury prevention benefit of the intervention programme to the lower-limb and head and neck result in a programme that was beneficial in reducing overall targeted injury, and should be recommended for use in men's community rugby clubs.

7.2 Future directions

The research questions proposed in this thesis have been addressed for the first time in men's community rugby union. This section outlines potential future studies that would add to this research and advance knowledge of injury prevention beyond these original investigations.

Having demonstrated the rugby injury prevention programme to be efficacious in reducing injury in a cross-section of men's community rugby clubs, a logical next step is to target national implementation in England. The approach taken during Chapter 6 was a pragmatic approach to maximise carryover to the real world context, despite being conducted as a controlled trial. In chapter 6, programme delivery was the only point of direct contact with intervention clubs, following which clubs could choose to implement the programme or not. This is similar to the situation when coaches attend a training course – the coaches would receive initial training following which they choose whether to implement the programme as delivered or not. However, further work is necessary to achieve this. During the pilot study 50% of teams dropped out of the study following which modifications to the programme were made to facilitate implementation and consequently, aid retention for the randomised control trial (Chapter 6). However, despite these changes 50% of the clubs in the RCT also dropped out. To achieve effective implementation nationwide, behaviour change of club delegates is necessary. Potential means to accomplish this may include further development of the prevention programme, with input from the players (i.e., moving beyond the delivery-agent to the player as the end user). Another approach may involve resource development such as the use of mobile APPs thus enabling access though electronic tablets or mobile phones. A multi-modal approach reflecting the efforts of BokSmart (Viljoen and Patricios, 2012) and RugbySmart (RugbySmart, 2001) are likely ways to achieve a beneficial reduction in the burden of injury. In England this could be achieved through promotion of the prevention programme alongside initiatives such as Headcase (RFU, 2015c), and through coach education courses. By promoting injury prevention behaviour at all levels of rugby, from the professional game to grass roots levels, the benefits of participation in rugby will be maintained without the economic burden associated with injury. Following intervention programme dissemination the effectiveness of the intervention programme (Chapter 6) is needed. This may be achieved through ongoing injury surveillance alongside club based surveys to determine the adoption and maintenance of the intervention by coaches in the real world environment, and feedback from clubs will help inform dissemination strategies.

Further research is needed to identify the cause of the reduction in concussion following implementation of the movement control exercise intervention. Possible explanations would include improved muscle function about the neck that resulted in reduced rotational accelerations of the head. A study is warranted where players are randomised into intervention (potentially only including self-resisted neck strength) or control (normal practice, excluding neck strength exercise) groups and have their neck strength and electromyograph activity (as a measure of activation) measured pre and post implementation. Ideally this would be conducted alongside normal rugby competition with ongoing surveillance to identify whether a) the intervention does increase neck strength, and b) whether the intervention group demonstrates a reduced incidence of concussion. Should the study support the intervention, the results would have far reaching impact across sports where concussion is a major focus at present, as the neck strength exercise is easily implementable, low cost, requires minimal training and can be performed anywhere.

A different mechanism worth considering is that post intervention, players have improved capacity for cutting and stepping manoeuvres enabling them to avoid contact events that would otherwise cause concussion. This would require further surveillance alongside match analysis to look at the mechanisms of injury of the intervention and control arms to determine the propensity of concussion by contact event. However, assuming a similar sample of clubs would be necessary, the match-analysis required would be very demanding in terms of time.

In order to have the greatest possible impact on player welfare, a multi-nation study would grant the opportunity not only to re-affirm the results of this initial study but also to conduct further research into the implementation facilitators and barriers across societies, necessary for effective programme translation and programme dissemination globally. This would require collaboration between national governing bodies and stakeholders providing medical care / insurance. However, such an approach would enable programme effectiveness to be evaluated in similar fashion to the FIFA 11 and 11+ programmes (Bizzini et al., 2013), and ultimately reduce the injury and economic burden of rugby worldwide.

7.3 Thesis conclusion

The aim of this thesis was to improve player welfare, by reducing the burden of sports injury in men's community rugby union. This was achieved through the course of 4 novel research questions.

This research has demonstrated for the first time that concussion and lower-limb injury can be reduced through the routine practice of a movement control exercise programme in men's community rugby. English men's community rugby boasts one of the world's largest rugby playing populations. Injury is one of the top reasons for players retiring from the game as well as presenting a socio-economic burden. Rugby as a sport is also under increased scrutiny regarding injury, where concussion is a key focus. Using a research informed approach, this research produced an intervention programme efficacious at reducing the injury burden of men's community rugby. This research demonstrated that while pre-season screening using the Functional Movement Screen™ score is associated with injury risk, granted the resources available to community clubs, the time necessary to conduct FMS testing, follow-up assessments and treatment would be far better invested into the application of better warm-up practice, such as that provided by the movement control exercise programme. It is hoped that the findings of this present research is used by stakeholders throughout the sport where there is little reason to suggest that this programme wouldn't also be efficacious in women's and youth rugby too.

The results from this work provide an original contribution to player welfare initiatives and provides a means of injury prevention that has important implications for future injury prevention policy and research, and ultimately may make the game safer.

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APPENDIX

Appendix A. Participant information sheet – (Chapter 3)

RFU Community Injury Surveillance Project (CRISP) 2013/14
Player Information Sheet

An investigation of injuries sustained and risk factors of injury by rugby union players at English Community level clubs.

Principal Investigator: **Matthew Attwood**
Other investigators: Keith Stokes, Grant Trewartha Simon Roberts

You are invited to take part in a research study of injuries sustained during matches involving first team squad players registered with English community level clubs participating in the RFU community playing levels 3-9. The study is fully supported by the Rugby Football Union. Before deciding whether to take part, it is important that you understand why the study is being undertaken and whether it will affect you. Take time to the read the following information carefully; if there are any aspects of the study that you do not understand, please discuss them with a member of your medical team or contact us for further information. When you have read and fully understood the information and you wish to be included in the study, you will be asked to sign the attached Player Consent Form for the 2013-2014 season. The Principal Investigator responsible for the study is Matthew Attwood at the University of Bath and he has been running the Community Rugby Injury Surveillance Project for five years.

Background to the study
The aim of this study is to determine the incidence, types and causes of injuries sustained by English community level rugby union players in match play. Additional information will be collected via a questionnaire to determine lifestyle risk factors for injury. The match play injury information will provide on-going data collection and enable comparisons to be made with similar data collected since 2008. The additional information will allow the research team to determine whether individual characteristics such as training habits and lifestyle affect the risk of injury. The study will run for one year, beginning during the 2013 pre-season period. Injury surveillance studies of this type provide data that help to monitor levels of injury risk and to develop injury prevention, treatment and rehabilitation programmes in rugby union.

What does the study involve?
Medical personnel at each club will record the details of all match injuries sustained by players in their club's 1st team. This data will be analysed by researchers in the Department for Health at the University of Bath.

Who is being asked to participate in the study?
All first team squad players in clubs participating league competitions within RFU playing levels 3-9 are being asked to take part in the study.

Do players have to take part?
Participation in the study is voluntary. You do not have to take part in the study but the more players who take part, the more comprehensive the data will be. If you decide to take part, you must sign the attached consent form to confirm you have been provided with this information and you agree to be included in the study. You are free to withdraw from the study by contacting us at any time without giving a reason.

What do I have to do?
Your club's medical staff will record the information about any injuries you sustain during match play. In addition, you will be asked to complete a questionnaire detailing information which may relate to your injury risk. This questionnaire will take you approximately 10 minutes to complete.

Are there any risks from taking part?
You will not be exposed to any other risk beyond your normal rugby activities with your club.

Will information about my injuries be kept confidential?
In accordance with the Data Protection Act, we must obtain your permission to collect information about your injuries during the course of this study. All information collected in the study is recorded and stored anonymously using a player identification code on a database at the University of Bath.

What will happen to the data obtained from the research study?
The data collected will be collated and analysed by researchers at the University of Bath in order to produce summary information about the incidence, severity, types and causes of injuries sustained in community rugby in England. No personal references will be made in any material published or report.

For further information, or if you have any questions, contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail:rfu-crisp@bath.ac.uk)

Appendix B. Participant consent form – (Chapter 3)

RFU Community Injury Surveillance Project (CRISP) 2013/14
Player Information Sheet

Player consent form

I confirm that I have read and understood the player information sheet for the above study and that I have had an opportunity to ask questions.

I agree to take part in the above study and give my consent for doctors, physiotherapists and fitness/ conditioning staff to supply medical information to the University of Bath. I acknowledge that such information will only be used for research, statistical and other analysis purposes, and that personal references shall not be made in any report or other published material.

I understand that all the information provided on my injuries and training will be treated in strict confidence and will remain anonymous.

I understand that I have the right to withdraw from this study at any stage and that I will not be required to explain my reasons for withdrawing.

Name ____________________ Date ____________ Signature ________________

Following up certain injuries
As this project progresses, certain injuries and treatments might stand out as being particularly interesting because they become common, are easily preventable or because one specific type of treatment appears more effective than another. Understanding more about examples such as these will help to reduce the amount of time players are out of the game due to injury in future.

With your permission we would like to follow up some injuries and specific treatments for injuries in more detail as the extra information that we collect improves our understanding of preventing and treating injuries in rugby union. We would like your permission to keep your contact details on file so that in future we can ask you whether you would like to fill in a questionnaire about an injury that you sustain or a treatment that you receive that might be of particular interest.

If you are happy for us to do this, please provide your email address on the consent form. It does not mean that you are committed to completing any questionnaires or answering any questions in the future, just that you consent to us contacting you at a later date.

If you do not wish to be contacted in future, please **DO NOT** provide your email address on the consent form. You can still be part of the main study.

E-mail address ________________________________

OFFICE USE ONLY

CLUB [ ]

PLAYER REGISTRATION NUMBER [| | | | | | |]

For further information, or if you have any questions, contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail:rfu-crisp@bath.ac.uk)

Appendix C. FMS Club participant information – (Chapter 3)

Community Rugby Injury Surveillance Project (CRISP) – Risk Factors 2013-2014

Club participation information

Thank you for your interest in this Project. The purpose of this information sheet is to provide information on the reason for undertaking the research and what exactly would be required of your club if you wish to participate.

Background

As you might be aware, rugby union has one of the highest reported injury incidence rates compared with other team sports, with the potential for severe injuries. Through the community rugby injury surveillance project there is now growing understanding of the frequency, type and causes of injury over a range of playing levels in the English community game. This Project is funded by the RFU Injured Players Foundation on behalf of Community Rugby and coordinated by members of the Sport, Health and Exercise Science research group at the University of Bath. This Project has now been established and run over the last five seasons. However, the information gathered to date has not focussed on whether certain characteristics, training habits and lifestyle factors affect the risk of injury.

Purpose

Now that there is an established injury surveillance system in English community rugby, the purpose of this study is to continue to build on our current information pertaining to the risk of injury in individual players. By also continuing the injury surveillance of match play injuries, it will be possible to determine whether individual characteristics, training and dietary habits, functional movement competency and physical fitness can be associated with the risk of injury.

What is involved in participating?

1. All participating clubs:

Injury surveillance

Player baseline information
You will be asked to provide a list of all eligible 1st team squad players, with basic information such as the name, playing position and date of birth for each player.

Match squad list
A form should also be completed for each 1st team match to show which players from the 1st team squad played.

Time-loss injuries
Your club will be asked to provide some information regarding injuries which occur during 1st team matches in your club. A nominated person (usually the club physiotherapist or someone

who deals with injured players) will be asked to complete a simple form to catalogue any match injury which caused the player to miss one match or more.

Rugby lifestyle questionnaire
The research team will issue you with this questionnaire which you should provide to all 1st team squad players for completion. This questionnaire should take each player approximately 10 to complete and will contain questions on the player's physical activity and training and dietary habits. To ensure confidentiality, players will be provided with an envelope in which the completed questionnaire can be enclosed and sealed to ensure that club staff are not able access the player's responses.

We will provide an information pack containing all the resources you will require for the season such as instructions, copies of injury forms, pre-paid envelopes etc. There is also an option to submit information for the player baseline information, match squad list and time-loss injuries using a web-based format.

2. Optional for participating clubs:

Functional movement screening and fitness testing

If you wish to be included in this component of the study, the study team's researchers will organise an appropriate time to visit your club once during pre-season or early season the season. During the visit, the research team will assess the competency of each 1st team player on seven simple functional movement screening tests and performance in a battery of physical fitness tests. In addition, the research team will record each player's height, body mass, dominant arms and legs and ethnic origin. The club will not have to provide any resources for these tests other than a short period of the squad's training time for the researchers to conduct the tests.

Full support will be available at all times during the season via telephone and email contact for any possible questions concerning any aspect of the study. Further information can be found on the Project web pages, the address of which can be found at the foot of this letter.

Your participation in this project is entirely voluntary but we hope that you can see the importance of this project and wish to be involved. We understand that taking part will place an additional burden on your club but hopefully the benefits to your club and game as a whole will make this worthwhile. At the end of the season, all participating clubs will receive feedback reports on how their injury rates and players functional movement competencies compare with clubs of a similar standard. Should you have any questions about participation in this project, I will happy to provide further details.

Matthew Attwood
PhD Student
Email: rfu-crisp@bath.ac.uk
Office: 01225 384531
Mobile: 07890261228

RFU Community Rugby Injury Surveillance Project
http://go.bath.ac.uk/rfu-crisp

Appendix D. Time-loss injury form – (Chapter 3)

RFU COMMUNITY RUGBY INJURY SURVEILLANCE PROJECT (CRISP) 2013/2014 – Time-Loss Injury Form

SECTION 1 PLAYER INFORMATION

1.1CLUB CODE ☐

1.2 PLAYER ID NUMBER ☐ **(This number is on the player baseline form)**

1.3 DATE OF INJURY day/month/year ☐ ☐ ☐

1.4 DATE OF RETURN FROM THIS INJURY day/month/year ☐ ☐ ☐

SECTION 2 INJURY INFORMATION

2.3 WAS PLAYER REMOVED FROM PLAY? Yes ☐ No ☐

2.4 IF YES, WAS PLAYER REMOVED BY AMBULANCE? Yes ☐ No ☐

2.5 POSITION BEING PLAYED WHEN INJURED

Full Back	15	Right Wing	14	Left Wing	11
Outside Centre	13	Inside Centre	12	Fly Half	10
Scrum Half	9	L H Prop	1	Hooker	2
T H Prop	3	Left Lock	4	Right Lock	5
B S Flanker	6	O S Flanker	7	No. 8	8

2.6 NORMAL PLAYING POSITION (if different from above) ☐

2.7 TIME OF INJURY (MIN): 0-20 ☐ 21-40+ ☐ 41-60 ☐ 61-80+ ☐ unknown ☐

2.8 TIME PLAYER BEGAN MATCH: 0 ☐ 0-20 ☐ 21-40+ ☐ 41-60 ☐ 61-80+ ☐
(Use '0' if player started the match)

2.9 EQUIPMENT WORN
Thigh pads ☐ Chest pad ☐ Head guard ☐ Gum shield ☐
Shin guards ☐ Shoulder pads ☐ Cycling shorts ☐
Compression garments: Calf ☐ Full leg ☐ Upper body ☐

2.10 Is this a recurrence of a previous injury? (same type/site) Yes ☐ No ☐

2.11 Number of months since return from previous injury? ☐

2.12 Was player still being treated for the previous injury? Yes ☐ No ☐

For enquiries or clarification please contact: Simon Roberts: Tel: 01225 384531 or 07890261228
E-mail: rfu-crisp@bath.ac.uk

SECTION 3 CLASSIFICATION OF INJURY

3.1 SIDE OF BODY Right ☐ Left ☐ Bilateral ☐
Front ☐ Back ☐ N/A ☐

3.2 INJURED BODY PART (please refer to full list if appropriate part is not below)

H-Head	N-Neck	S-Shoulder	U-Upper arm	E-Elbow
R-Forearm	W-Wrist	P-Hand	C-Chest	D-Upper back
L-Lower back	O-Stomach	G-Groin/hips	B-Buttocks	T-Thigh
K-Knee	Q-Lower leg	A-Ankle/heel	F-Foot	X-Multiple areas

3.3 TYPE OF INJURY (please refer to full list if appropriate injury is not below)

S-Stress fracture	D-Dislocation	F-Fracture	M-Muscle tear/strain
H-Bruise/Haematoma	G-Dental injury	K-Laceration	T-Tendon injury
L-Ligament tear/sprain	Y- Spasm/winding	X-Respiratory	J-Jar/joint
R-Complete tendon rupture	N-Nerve injury (stingers/concussion)		Z-Pain/undiagnosed
C-Cartilage	O-Organ damage	I-Virus/illness	

Please refer to the full Orchard Coding (OSICS 8) list to enter a 3-character injury code below.
If a specific diagnosis of three characters is not possible, enter one letter from 3.2 and one from 3.3.

3.4 DIAGNOSIS CODE (OSICS 8) 3.2 Letter ☐ 3.3 Letter ☐ ☐

3.5 TREATMENT (tick all applicable)
Pitch side: First aider ☐ Sports Therapist ☐ Physiotherapist ☐ Doctor Nurse/paramedic ☐ Chiropractor ☐ Osteopath ☐
Referred to: Sports Therapist ☐ Physiotherapist ☐ Hospital ☐ Surgeon/Specialist ☐ Chiropractor ☐ Osteopath ☐ GP ☐

Additional details ☐

SECTION 4 INJURY EVENT

4.1 CONTACT (If 'Tackle collision': please also tick if player was 'Tackled' or 'Tackling')
Tackled ☐ Tackling ☐ Tackle collision (no use of arms) ☐ Collision – non-tackle ☐
Ruck ☐ Maul ☐ Collapsed Maul ☐ Scrum ☐ Collapsed scrum ☐ Lineout ☐
Punched ☐ Stamped ☐ Other ☐

4.2 NON-CONTACT
Running ☐ Changing direction ☐ Side stepping ☐
Twisting/turning ☐ Jumping ☐ Kicking ☐ Other ☐

4.3 Was a penalty given relating to the injury event? Yes ☐ No ☐ For ☐ Against ☐

Details of penalty award ☐

Appendix E. Match report form– (Chapter 3)

RFU INJURY SURVEILLANCE PROJECT 2013-2014
MATCH REPORT FORM

CLUB NAME		CLUB CODE		DATE OF MATCH	

Level	Competition	Score		Weather conditions		Ground conditions	
5-9	League = L Friendly = F Local cup = K National cup = N	For	Against	Sun = 1 Cloud = 2	Dry = 3 Rain = 4 Hail = 5 Snow = 6	Soft = 1 Hard = 2	Dry = 3 Wet = 4 Frozen = 5

Please complete the team list for this match –
Please indicate whether the player sustained a time-loss injury

Position	Player Name	Time-loss injury?	Position (subs)	Player Name	Time-loss injury?
1			16		
2			17		
3			18		
4			19		
5			20		
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Interchanges: Please enter all interchanges which take place during the match

Inter-change	Team number (1-20) of player coming on	Team number (1-20) of player being replaced	Match Quarter			
			0-20	20-40+	40-60	60-80+
1						
2						
3						
4						
5						
6						
7						
8						

For enquiries contact: Simon Roberts Tel: 01225 384531 Mob: 07890261228

E-mail: rfu-crisp@bath.ac.uk

Appendix F. Time-loss injury master list – (Chapter 3)

RFU INJURY SURVEILLANCE PROJECT 2013-2014
Time-loss injury master list

CLUB CODE	
CLUB NAME	

This form is to help you to keep track of injured players to make it easier for you to complete and return the time loss injury form.

You should not return this form.

Player ID code	Player name	Date of injury	Date of return to play	Time loss injury form returned?

Appendix G. Player baseline information form – (Chapter 3)

RFU Community Injury Surveillance Project (CRISP)
Player Baseline Information Form

CLUB CODE:

Player's ID number Use this code for any time-loss injury forms	Player (Family name, initial)	Normal playing position	Date of birth (dd/mm/yy)	Height (cm)	Body mass (Kg)	Dom Leg	Dom Arm	Ethnic origin
1		Please be specific – see guidance	…. /…. /….					
2		Please be specific – see guidance	…. /…. /….					
3		Please be specific – see guidance	…. /…. /….					
4		Please be specific – see guidance	…. /…. /….					
5		Please be specific – see guidance	…. /…. /….					
6		Please be specific – see guidance	…. /…. /….					
7		Please be specific – see guidance	…. /…. /….					
8		Please be specific – see guidance	…. /…. /….					
9		Please be specific – see guidance	…. /…. /….					
10		Please be specific – see guidance	…. /…. /….					
11		Please be specific – see guidance	…. /…. /….					
12		Please be specific – see guidance	…. /…. /….					
13		Please be specific – see guidance	…. /…. /….					
14		Please be specific – see guidance	…. /…. /….					
15		Please be specific – see guidance	…. /…. /….					
16		Please be specific – see guidance	…. /…. /….					
17		Please be specific – see guidance	…. /…. /….					

For enquiries or clarification please contact : Dr Simon Roberts
University of Bath, Bath, BA2 7AY
Tel: 01225 384531; email: rfu-crisp@bath.ac.uk

RETAIN A COPY OF THE COMPLETED FORM FOR REFERENCE PURPOSES
(Reviewed: May 2013)

Community Rugby Injury Surveillance Project (CRISP) – Warm-up practices
2014-2015

Club participation information

Introduction
The purpose of this information sheet is to introduce you to a research study involving an investigation into pre-training warm-up strategies and injury rates, for which we are currently recruiting clubs within RFU playing levels 4-7 to participate.

This Project is funded by the RFU on behalf of Community Rugby and coordinated by members of the Sport, Health and Exercise Science research group at the University of Bath.

Background
As you might be aware, rugby union has a relatively high injury incidence rate compared with other team sports, with the potential for severe injuries. The RFU community rugby injury surveillance project (CRISP) which has been running over the last six seasons has helped us to understand the frequency, type and causes of injury over a range of playing levels in the English community game as well as player physical and fitness characteristics. While it is important to continue to monitor injury patterns in the community game, the investigation of pre-training warm-up practices is important, given the potential benefits these can have on the training preparation of players.

Purpose
Now that there is an established injury surveillance system in English community rugby, the purpose of this study is to continue this injury monitoring so that any changes injury rate and type can be detected over time. In addition an investigation into pre-training warm-up practices will help to provide information on the preparation of players for training.

What is involved in participating?

Injury surveillance

Player baseline information
You will be asked to provide a list of all eligible 1st team squad players, with basic information such as the name, playing position and date of birth for each player. For a player to be included in the study, they must read and signed an player informed consent form.

Match squad list
A form should also be completed for each 1st team match to show which players from the 1st team squad played.

Time-loss injuries
Your club will be asked to provide some information regarding injuries which occur during 1st team matches in your club. A nominated person (usually the club

physiotherapist or someone who deals with injured players) will be asked to complete a simple form to catalogue any match injury which caused the player to miss one match or more.

Player SMS
Once per week, consenting players will be sent one SMS message by the research team asking whether they sustained an injury in rugby related activity that week to which they will answer 'Yes' or 'No'. If the answer 'Yes', they will be asked three further questions about the injury, each requiring single word answers. This feature will only involve contact between the players and the research team.

Delivery of a prescribed warm up
The research team will provide you with a warm-up specifically designed for the demands of rugby. Although this will comprise mainly prescribed exercises, there will be some menu options to choose exercises to maintain variation between sessions. This should be carried out at the start of each training session during the season. The club should nominate a person within the club (normally the coach or whoever delivers the training warm-up) who will be responsible for delivering the training warm-up. This person will be visited by the research team prior to the start of pre-season so that they are fully trained in how to deliver warm-up protocol. An attendance form should be completed for each session throughout the season to show which players attended. During the season, you will be asked your opinion in the form of a short interview/questionnaire on various aspects of the warm-up.

The research team will provide all necessary resources
We will provide an information pack containing all the resources you will require for the season such as instructions, copies of injury forms, pre-paid envelopes etc. There is also an option to submit information for the player baseline information, match squad list and time-loss injuries using a web-based format. The prescribed warm-up will not require any specialist equipment which the club would have to purchase.

Full support will be available at all times during the season via telephone and email contact for any possible questions concerning any aspect of the study. Further information can be found on the Project web pages, the address of which can be found at the foot of this letter.

Your participation in this project is entirely voluntary but we hope that you can see the importance of this project and wish to be involved. We understand that taking part will place an additional burden on your club but hopefully the benefits to your club and game as a whole will make this worthwhile. At the end of the season, all participating clubs will receive feedback reports on how their injuries compare with clubs of a similar standard. Should you have any questions about participation in this project, I will happy to provide further details.

Matthew Attwood
PhD student
Email: rfu-crisp@bath.ac.uk
Office: 01225 384531

RFU Community Rugby Injury Surveillance Project
http://go.bath.ac.uk/rfu-crisp

Appendix I. Participant consent form – (Chapter 4)

RFU Community Injury Surveillance Project (CRISP) 2014/15
Player Information Sheet

An investigation of training warm-up practices and injury in rugby union players at English Community level clubs.

Principal Investigator: Matthew Attwood
Other investigators: Keith Stokes, Grant Trewartha, Simon Roberts

You are invited to take part in a research study investigating training warm-up practises and injuries sustained during matches involving first team players registered with RFU English community clubs (levels) 3-9. The study is fully supported by the Rugby Football Union. Before deciding whether to take part, it is important that you understand why the study is being undertaken and whether it will affect you. Take time to the read the following information carefully; if there are any aspects of the study that you do not understand, please discuss them with a member of your medical team or contact us for further information. When you have read and fully understood the information and you wish to be included in the study, you will be asked to sign the attached Player Consent Form for the 2014/15 season. The Principal Investigator responsible for the study is Dr Simon Roberts at the University of Bath and he has been running the Community Rugby Injury Surveillance Project for six years.

Background to the study
The aim of this study is to investigate training warm-up practices and injuries in English community club rugby. The information collected on warm-ups will allow the research team to understand more about how these are implemented in community rugby. The match play injury information will provide data collection which has been ongoing since 2008, allowing any changes in injury patterns over this time to be detected. Injury surveillance studies of this type provide data that help to monitor levels of injury risk and to develop injury prevention, treatment and rehabilitation programmes in rugby union.

What does the study involve?
The research team will provide coaching staff at your club with a prescribed warm-up protocol which they will be asked to deliver at the start of each training session during the 2014/15 season. Medical personnel at each club will record the details of all match injuries sustained by players in your club's 1st team causing the player to miss one match or more. If you take part you will be asked to respond to one SMS message per week, sent directly from the research team, to indicate whether you have sustained a rugby-related injury that week. This data will be analysed by researchers in the Department for Health at the University of Bath. The study will run for the entire 2014/15 season including pre-season.

Who is being asked to participate in the study?
All first team squad players in clubs participating in league competitions within RFU playing levels 4-7 are being asked to take part in the study.

Do players have to take part?
Participation in the study is voluntary. You do not have to take part in the study but the more players who take part, the more comprehensive the data will be. If you decide to take part, you must sign the attached consent form to confirm you have been provided with this information and you agree to be included in the study. You are free to withdraw from the study by contacting us at any time without giving a reason.

What do I have to do?
You will be required to participate in the prescribed warm-up protocol which your club coaching team will deliver at the start of each club training session. Your club's medical staff will record the information about any injuries you sustain during match play. You will be asked to complete one short questionnaire and to provide your mobile telephone number to the research team. Once per week during the rugby season you will be sent one SMS message by the research team asking whether you sustained an injury during the previous week. We ask that you answer this text with either a 'Yes' or 'No'. If you answer 'Yes' you will be asked three further questions about the injury, each requiring single word answers.

Are there any risks from taking part?
You may be unaccustomed to some of the warm-up exercises but these will be simple to perform initially with the level of difficulty increasing as the season progresses.

Will information about my injuries be kept confidential?
In accordance with the Data Protection Act, we must obtain your permission to collect information about your injuries during the course of this study. All information collected in the study is recorded and stored anonymously using a player identification code on a database at the University of Bath.

For further information contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail:rfu-crisp@bath.ac.uk)

RFU Community Injury Surveillance Project (CRISP) 2014/15
Player Information Sheet

What will happen to the data obtained from the research study?
The data collected will be collated and analysed by researchers at the University of Bath in order to produce summary information about the incidence and nature of injuries and training practices in English community rugby. No personal references will be made in any material published or report.

Player consent form

I confirm that I have read and understood the player information sheet for the above study and that I have had an opportunity to ask questions.

I agree to take part in the above study and give my consent for doctors, physiotherapists and fitness/ conditioning staff to supply medical information to the University of Bath. I acknowledge that such information will only be used for research, statistical and other analysis purposes, and that personal references shall not be made in any report or other published material.

I understand that all the information provided on my injuries and training will be treated in strict confidence and will remain anonymous.

I understand that I have the right to withdraw from this study at any stage and that I will not be required to explain my reasons for withdrawing.

Name ______________ Date ______________ Signature ______________

OFFICE USE ONLY

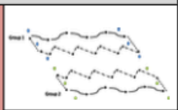
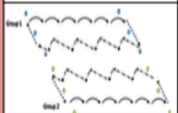
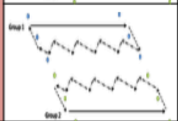
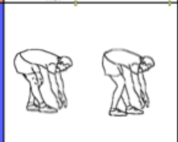
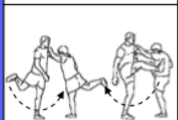
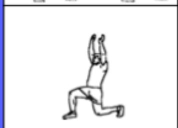
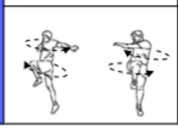
CLUB [ ]

PLAYER REGISTRATION NUMBER [| | | | | | |]

For further information contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail:rfu-crisp@bath.ac.uk)

Appendix *J*. The six phases of the pilot control programme as provided to clubs during the 2014/2015 pilot trial – (Chapter 4)

CRISP INJURY PREVENTION PROTOCOL—**Phase 1**

PHASE 1		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
Preparation		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
Preparation		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk**	• Walk 3 paces and gentle reach towards alternating feet • Keep the back straight and look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight	1	2 x 15m
Dynamic Stretching		**Partner leg swings**	• Hold partners same sided shoulder • Swing outer leg through to full flex-ion and extension of hip	1 each leg	10/leg
Dynamic Stretching		**Lunges walk with arm raise**	• Lunge forwards raising both arms high as possible • Do not let the back knee con-tact the ground • Keep the torso upright through-out	1	2 x 15m
Dynamic Stretching		**Knee Across (countermove ment) Skips**	• High skip with a counter movement or upper and lower body • Aim for maximum rotation • Keep the knee high • Stay high on the balls of the feet.	1	2 x 15m

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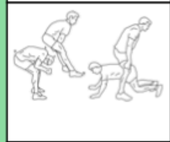
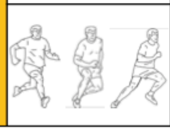
Matthew Attwood Tel: 01225 385176 Mob: 07538634023

CRISP INJURY PREVENTION PROTOCOL—**Phase 1**

PHASE 1		Exercise	Key points	Sets	Reps
Strength & Stability		**Cheek Touch**	• Partners grasp each others wrists. Alternate after 30 s • Legs shoulder width apart • Aim to touch opponents cheek while he resists. • Keep arms shoulder height	2	30s
Strength & Stability		**Leap frog and unders**	• Partner 1 - stable position with legs straddled, tucking chin onto chest. • Soft landing at end of leap • Push on partners shoulders • Avoid chest touch ground on crawl through.	1 each player	5
Strength & Stability		**Kneeling wrestle**	• Clasp partner with head on left hand side • Try and force opponent to the ground on left side. • Swap clasp (head on right side) and change direction (force partner to the right).	1 each side	15s
Strength & Stability		**Stability crouch**	• Eyes looking forwards • Feet wide • Flat back • Head looking up • Resist partners pressure	1 each	30s
Speed & Agility		**Kneeling start sprint**	• In 15m channel • Sprint from kneeling • Drive arms • 90% effort	1	2 x 15m
Speed & Agility		**Lying start sprint**	• In 15m channel • Legs must be straight before getting up • Player laying prone, rises to sprint • 90% effort	1	2 x 15m
Speed & Agility		**Pre-planned cutting**	• In 15m channel • 10m run—cut left or right for 5m • Over emphasise direction change • Drive hard out of 'cut' position • 90% effort	1	2 x 15m

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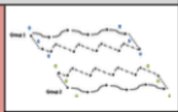
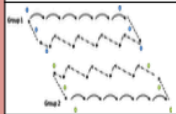
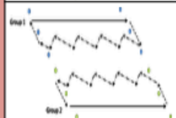
CRISP INJURY PREVENTION PROTOCOL—**Phase 2**

PHASE 2		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
Preparation		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
Preparation		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk**	• Walk 3 paces and gentle reach towards alternating feet • Keep the back straight and look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight	1	2 x 15m
Dynamic Stretching		**Partner leg swings**	• Hold partners same sided shoulder • Swing outer leg through to full flexion and extension of hip	1 each leg	10/leg
Dynamic Stretching		**Walking lunge with twist**	• Lunge forwards lowering until the back knee is near the ground • Hold positon and rotate the torso to the left, then right • Keep the torso upright	1	2 x 15m
Dynamic Stretching		**Knee Across (countermovement) Skips**	• High skip with a counter movement or upper and lower body • Aim for maximum rotation • Keep the knee high • Stay high on the balls of the feet.	1	2 x 15m

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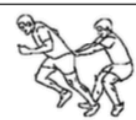
CRISP INJURY PREVENTION PROTOCOL—**Phase 2**

PHASE 2		Exercise	Key points	Sets	Reps
Strength & Stability		**Grappling – hands to shoulders**	• Partners 1 and 2 stand facing each other, about 50cm apart. • Partner starts with his hands on partner 2's waist and attempts to get both hands onto Partner 2's shoulders. Partner 2 attempts to bock him.	1 each for 15s-	1
Strength & Stability		**Flip and contest**	• Partner 1 crouches on hands and feet with knees off the ground. Partner 2 stands over and moves around him • On coach's signal, partner 2 reaches under partner 1 to pull his furthermost arms and thigh, to flip him onto his back. • Partner 2 gets back to his feet to contest the ball for about 3 seconds.	1 each player	1
Strength & Stability		**Leap frog and unders**	• Partner 1 - stable position with legs straddled, tucking chin onto chest. • Soft landing at end of leap • Push on partners shoulders • Avoid chest touch ground on crawl through.	1 each side	15s
Strength & Stability		**Kneeling wrestle**	• Clasp partner with head on left side • Try and force opponent to the ground on left side. • Swap clasp (head on right side) and change direction (force partner to the right).	1 each player	5
Speed & Agility		Graduated sprints	• Players run over 20m, making sudden increases in speed at 5, 10 and 15m • Start at 50% (0-5m) • Finish at maximum pace	1	2 x 20m
Speed & Agility		Partner resisted sprints	• Partner 2 holds onto Partner 1's waist • Partner 1 starts sprinting while be resisted over the first 5m • After 5m partner 2 releases and partner sprints over the next 15m	1 each player	1 x 20m
Speed & Agility		**Pre-planned cutting**	• In 15m channel • 10m run—cut left or right for 5m • Over emphasise direction change • Drive hard out of 'cut' position • 90% effort	1	2 x 15m

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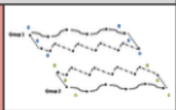
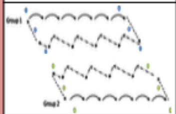
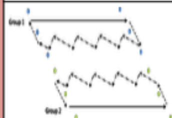
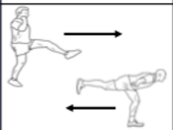
CRISP INJURY PREVENTION PROTOCOL—**Phase 3**

PHASE 3		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
Preparation		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
Preparation		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk (forwards & Backwards)**	• For 15m walk 3 paces and gentle reach towards alternating feet • Keep back straight, look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight • Repeat, going backwards (15m)	1	1 x 15m forwards, 1 x 15m back-wards
Dynamic Stretching		**Hurdle Walks (forwards & Backwards)**	• Walk forward emphasising high knee left and knee extension. • Emphasis high arm drive • Maintain good posture and slow controlled movement • For backwards, lean forward at the hip and extend leg back	1	1 x 10m forwards, 1 x 10m back-wards
Dynamic Stretching		**Jog with hip in/out**	• Jog forward bringing alternate knees inwards from a wide posi-tion to straight in front. • After 10 m, players jog back-wards, moving the knee from in front to the side, then down. • Make two short step between each knee in/out	1	2 x 15m
Dynamic Stretching		**Walking lunge with Twist (forwards and Backwards)**	• Lunge forwards lowering until the back knee is near the ground • Hold positon and rotate the torso to the side of leading leg • Keep the torso upright • Repeat going backwards	1	1 x 15m forwards, 1 x 15m back-wards

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CRISP INJURY PREVENTION PROTOCOL—**Phase 3**

PHASE 3		Exercise	Key points	Sets	Reps
Strength & Stability		**Grappling partner lift**	• Partners face each other standing 50 cm apart with hands on other part-ner's shoulders. • On a signal, both partners attempt to get both arms round the opposing partner's lower back. • 'Winner' is the partner who lifts the other off the ground. • Attempt to lift partner under control	1 each for 15s-	1
Strength & Stability		**Flip and con-test**	• Partner 1 crouches on hands and feet with knees off the ground. Partner 2 stands over and moves around him • On coach's signal, partner 2 reaches under partner 1 to pull his further-most arms and thigh, to flip him onto his back. • Partner 2 gets back to his feet to con-test the ball for about 3 seconds.	1 each player	1
Strength & Stability		**Round the world piggy back**	• Partner 1 adopts a stable position squatting position with a straight back • Partner 2 climbs onto partner 1's back as if piggybacking. • Both partners work together to move partner 2 around the torso of partner 1 without touching the ground. Final position is back to the piggyback	1 each player	1
Strength & Stability		**Floor to standing**	• Partner 1 lies on their back on ground • Partner 2 stands over. • On coach's signal, partner 1 attempts to stand up, while partner 2 attempts to keep him on the ground.	1 each player	1
Speed & Agility		**Sprint stops**	• Players accelerate maximally over 10m then must come to a complete stop within 2 m	1	2 x 12m
Speed & Agility		**5 m drill to 15 m sprint**	• Players performs sprint drill for 5m then immediately transfer into 15m sprint • 5m drill can be decided by the coach: from fast feet, high knees, heel flicks	1	2 x 20m
Speed & Agility		**Player un-planned cutting drill**	• Players run 10m, then cut left or right for 5m depending on hand signal of coach • Over emphasise direction change • Drive hard out of 'cut' position	1	2 x 20m

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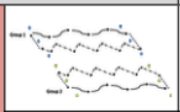
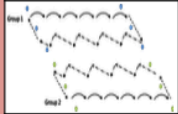
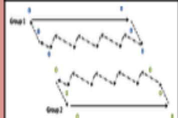
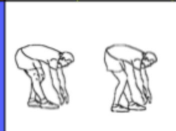
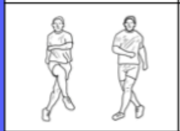
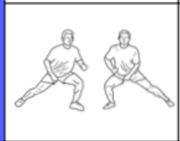
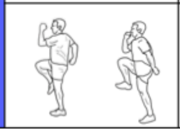
CRISP INJURY PREVENTION PROTOCOL—**Phase 4**

PHASE 4		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk (forwards & Backwards)**	• For 15m walk 3 paces and gentle reach towards alternating feet • Keep back straight, look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight • Repeat, going backwards (15m)	1	1 x 15m forwards, 1 x 15m back-wards
		**Carioca** (forwards and backwards)	• Start side on to movement direction • Bring rear leg across in front of leading leg • Then bring same leg behind • Change direction after 15m and swap working leg	1	2 x 15m
		**Lateral Lunge**	• Player steps left, bending the left knee and keeping the right leg straight. • Return to the upright position, and perform movement on opposite side. • Keep the back straight throughout. • Feel stretch on the straight leg	1	5 each side
		**Speed marching drill**	• Player stands on one leg in sprint posture with raised leg flexed at 90 degrees at hip and knee. Hold for 2 seconds. • On signal, player performs a rapid switch of leading knee and arm, then returns to start position	1	10: 5 on each leg

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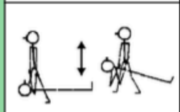
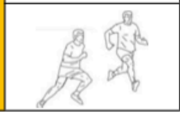
CRISP INJURY PREVENTION PROTOCOL—**Phase 4**

PHASE 4		Exercise	Key points	Sets	Reps
Strength & Stability		**Grappling Hands to shoulders**	• Partners face each other standing 50 cm apart with hands on other partner's shoulders. • On a signal, both partners attempt to get both arms round the opposing partner's lower back. • 'Winner' is the partner who lifts the other off the ground. • Attempt to lift partner under control	1 each for 15s-	1
		Partner push-up step ups	• Both partners adopt a press up position with partner 1 side on to partner 2 to create a T shape. • Partner 2 performs step-ups by marching with both hands up onto the back of partner 1 and down again. • Both partners work hard to keep their back straight	1 each player	6 each
		**Round the world piggy back**	• Partner 1 adopts a stable position squatting position with a straight back • Partner 2 climbs onto partner 1's back as if piggybacking. • Both partners work together to move partner 2 around the torso of partner 1 without touching the ground. Final position is back to the piggyback	1 each player	1
		**Partner Pull ups**	• Partner 1 lies down on back • Partner 2 stands over in a strong squat • Partner 1 grasps partner 2's forearms • Partner 2 tucks elbows into body • Partner 1 performs a pull up	1 each player	10 each
Speed & Agility		**Backpedal sprints**	• Players start by running backwards for 15m at 90%. • After 15m, they immediately sprint forward for 15m	1	2 x 15m
		**5 m drill to 15 m sprint**	• Players performs sprint drill for 5m then immediately transfer into 15m sprint • 5m drill can be decided by the coach: from fast feet, high knees, heel flicks	1	2 x 20m
			• Players on line facing coach • Coach uses hand signals to direct players randomly • Finish with at least 10 m sprint • Players always face forwards	1	1 x 20m

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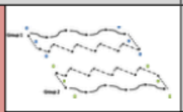
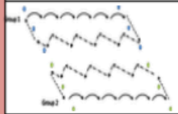
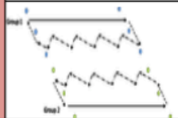
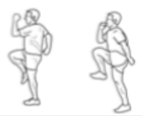
CRISP INJURY PREVENTION PROTOCOL—**Phase 5**

PHASE 5		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk (forwards & Backwards)**	• For 15m walk 3 paces and gentle reach towards alternating feet • Keep back straight, look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight • Repeat, going backwards (15m)	1	1 x 15m forwards, 1 x 15m back-wards
		**Ankle flicks**	• Players run forward keeping legs straight out in front • No leg back swing • Keep legs straight, aim for high 'flick' • Emphasise arms movement	1	1 x 15m
		**Side squad**	• Player stands with feet wider than shoulder width apart • performs a squat with knees bent to 90 degrees. • Player returns to standing, then pivots on one leg to turn to face opposite direction and repeat the squat movement	1	10
		**Speed march-ing drill**	• Player stands on one leg in sprint posture with raised leg flexed at 90 degrees at hip and knee. On signal, player performs a rapid switch of leading knee and arm, then returns to start position and holds position for 3 seconds.	1	10: 5 on each leg

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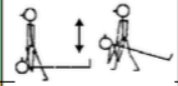
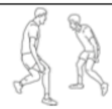
CRISP INJURY PREVENTION PROTOCOL—**Phase 5**

PHASE 5		Exercise	Key points	Sets	Reps
Strength & Stability		**Cheek Touch**	• Partners grasp each others wrists. Al-ternate after 30 s • Legs shoulder width apart • Aim to touch opponents cheek while he resists. • Keep arms shoulder height	2	30s
		**Partner push-up step ups**	• Both partners adopt a press up posi-tion with partner 1 side on to partner 2 to create a T shape. • Partner 2 performs step-ups by marching with both hands up onto the back of partner 1 and down again. • Both partners work hard to keep their back straight • Partner 2 performs movement slowly	1 each player	6 each
		**Stability crouch**	• Eyes looking forwards, head up • Feet wide • Flat back • Head looking up • Resist partners pressure	1 each player	30s
		**Partner Pull ups**	• Partner 1 lies down on back • Partner 2 stands over in a strong squat • Partner 1 grasps partner 2's forearms • Partner 2 tucks elbows into body • Partner 1 performs a pull up	1 each player	10 each
Speed & Agility		**Backpedal sprints**	• Players start by running backwards for 15m at 90%. • After 15m, they immediately sprint forward for 15m	1	2 x 15m
		**Sprint-stop-sprint**	• Player sprints for 10 m then stop within 2 m before sprinting another 10 m • Player must come to a complete stop between sprints • Emphasise fast feet for sprint phases	1	2 x 22m
		Coach-led agility with player part-ner mirroring	• Player in pairs, facing each other • One line of players face coach • Other line with backs to coach • Coach uses hand signals to direct players facing him • Other player backtrack mirroring movements of oncoming players	1	2 x 20m

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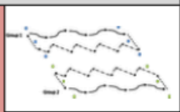
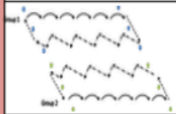
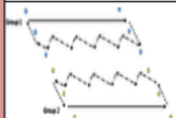
CRISP INJURY PREVENTION PROTOCOL—Phase 6

PHASE 6		Exercise	Key points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2 x 15m
		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	1	2 x 15m
		**2 point stance and accelerate** (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2 x 15m
Dynamic Stretching		**Hamstring Walk (forwards & Backwards)**	• For 15m walk 3 paces and gentle reach towards alternating feet • Keep back straight, look ahead. • Support weight on the back leg. • Maintain balance • Keep lead leg straight • Repeat, going backwards (15m)	1	1 x 15m forwards, 1 x 15m back-wards
		**Carioca** (forwards and backwards)	• Start side on to movement direction • Bring rear leg across in front of leading leg • Then bring same leg behind • Change direction after 15m and swap working leg	1	2 x 15m
		**Lunge walk with high knee drive**	• Start with lunge forward • Then push off front leg and drive rear knee up and out in front • Extend rear leg. • Extend front knee to land back on lunge position. • Aim for maximum range	1	20m
		**Speed marching drill** (moving forwards)	• Player stands on one leg in sprint posture with raised leg flexed at 90 degrees at hip • . On signal, player moves forward performing a rapid switch of leading knee and arm, then returns to start position and holds position for 3 seconds. • Repeat drill over 5 times over 10 m	1	5 over 10 m

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CRISP INJURY PREVENTION PROTOCOL—Phase 6

PHASE 6		Exercise	Key points	Sets	Reps
Strength & Stability		**Grappling Hands to shoulders**	• Partners face each other standing 50 cm apart with hands on other partner's shoulders. • On a signal, both partners attempt to get both arms round the opposing partner's lower back. • 'Winner' is the partner who lifts the other off the ground. • Attempt to lift partner under control	1 each-	20s
		**Bear crawl position with partner push**	• Partner 1 adopts bear crawl position maintaining a straight back parallel with the ground. • Partner 2 moves around partner 1, pushing at various points on the body of Partner 1 who attempts to resist movement.	1 each	30s
		**Floor to standing**	• Partner 1 lies on their back on the ground. Partner 2 stands over. On the coach's signal, partner 1 attempts to stand up, while partner 2 attempts to keep him on the ground. • Partner 1 attempts to get to a standing position even when partner 2 is trying to force him down • Allow about 10 seconds to compete.	1 each player	30s
Speed & Agility		**Partner resisted sprints**	• Partner 2 stand directly behind partner 1, taking hold of their waist. • Partner 1 starts sprinting while being resisted by partner 2 for 5 m, after which partner 2 releases and partner 1 sprints for a further 15 m	1	2 x 20m
		**Sprint-backpedal-sprint**	• Players start by sprinting forwards for 10 m then stopping immediately and running backwards for 10m then immediately sprint forward for 20m	1	2 x 10-10-20m
		**Coach-led agility with down-ups**	• One line of players face coach • Coach uses hand signals to direct players facing him: Forwards/back/left/right/down (to bear crawl position)/up • Include at least 2 bear crawl holds, each for about 3-5 seconds	1	1 x 20m

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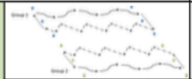
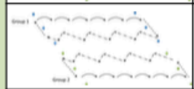
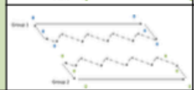
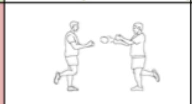
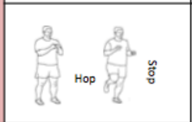
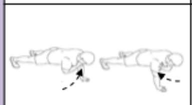
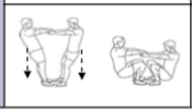
Appendix K. The six phases of the pilot intervention programme as provided to clubs during the 2014/2015 pilot trial – (Chapter 4)

CRISP INJURY PREVENTION PROTOCOL -**PHASE 1**

PHASE 1		Exercise	Key Points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	2	1
		**Stride-outs** (back skip on return)	• In 5m x 15m channels • Max distance with each bound • Drive the knee up • 60% effort	2	1
		**2 point stance and accelerate** (back skip on return)	• In 5m x 10m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	2	1
Balance		**Single leg balance, eyes open, passing object forwards**	• Maintain well aligned upright posture • Maintain balance • Keep legs apart.	1 each leg	30secs
		**Double legged take off, single leg land**	• Land softly • Maintain knee over 2nd and 3rd toes • Perform while looking forwards • Maintain balance for 4 seconds	1 each leg	5
Strength		**Hip Hop Ups**	• Focus on keeping the hips level • Drive through heel (not from lower back)	1 each leg	8
		**Side Plank**	• Focus on alignment Do not hitch / bend / twist at the hip.	1 each side	30 secs
		**Shoulder Tap**	• Maintain a neutral back position • Foot width as preferred • Perform with control • Each tap should take 3 seconds	1	30 secs
		**Partner Squat**	• Aim to sit bottom on to heels • Keep the torso upright • Have feet shoulder width apart • Knees over toes	1	8

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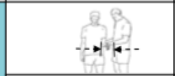
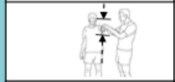
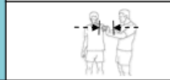
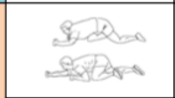
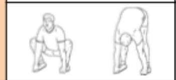
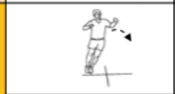
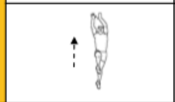
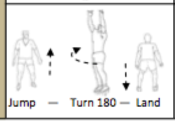
CRISP INJURY PREVENTION PROTOCOL -**PHASE 1**

		Exercise	Key Points	Sets	Reps
Shoulder Strength		**Internal/ External Rotation**	• Keep elbow in contact with body at all times • Do NOT push too hard – only 30% effort	1 each arm	10 secs
		**Abduction / Adduction**	• Arm at 45 degrees to body • No movement should occur during the exercise • 40-50% effort only	1 each arm	10 secs
		**Flexion / Extension**	• Arm should be at 90 degrees to body facing forwards • No movement should occur during the exercise • 40-50% effort only	1 each arm	10 secs
		**Horizontal Flexion**	• Arm should be at 90 degrees to body facing forwards • No movement should occur during the exercise • 40-50% effort only	1 each arm	10 secs
Mobility		**Spidey crawls**	• Keep hips as low as possible to the ground • Perform slowly with control • Knees should come to the side of the body (not underneath)	1	10m
		**Squat to stand**	• Feet shoulder width apart • Look forward and lift chest up during squat phase • Elbows inside knees at all times	1	10
Landing / C.O.D		**Cross jumps**	• Keep feet together • Balance for 2-3 seconds per jump	1	12
		**High ball jumps**	• Reach arms up above the head • Drive the front knee up toward the chest for maximum height during jump • Alternate legs • Land softly	1	10
Plyometrics		**Clap press-ups**	• Maintain shoulder hip and ankle alignment throughout. • Have arms at about 45 degrees to the body	1	10
		**180 jumps**	• Jump high as possible • Keep feet shoulder width apart • Land with knees bending over toes • Land softly	1	10

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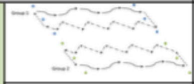
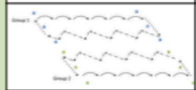
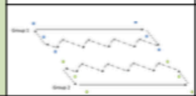
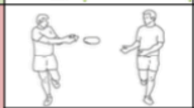
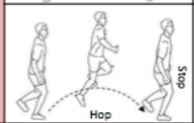
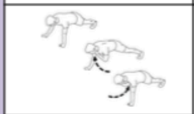
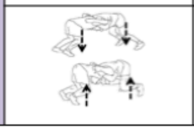
CRISP INJURY PREVENTION PROTOCOL -**PHASE 2**

PHASE 2		Exercise	Key Points	Sets	Reps
Preparation		Swerve Runs (back skip on re-turn)	• In 5m x 15m channels • Use full width channel • Head up looking forward • 50% Effort only	1	2
		Stride-outs (back skip on return)	• In 5m x 15m channels • Max distance with each stride • Drive the knee up • 60% effort	1	2
		2 point stance and accelerate (back skip on return)	• In 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 70% effort	1	2
Balance		Single leg balance, passing object sideways	• Maintain well aligned upright posture • Maintain balance • Keep legs apart.	1 each leg	30secs
		Single leg-ged take off, single leg land	• Land softly • Maintain knee over 2nd and 3rd toes • Perform while looking forwards • Maintain balance for 4 seconds	1 each leg	5
Strength		Hip hop up and hold.	• Focus on keeping the hips level • Drive through heel (not from lower back)	1 each leg	8 (5 sec hold)
		Hill climbers	• Minimise sideways weight shift • Bring knee outside of elbow • Foot only touches ground at start and end of movement	1 each side	30 secs
		Wide arm shoulder tap	• Hands wider than shoulders • Maintain a neutral back position • Perform with control • Each tap should take 3 seconds	1	30 secs
		Scrum 'drops'	• Secure bind with both hands • Flat back position through-out • Drop as low to ground as possible without touching it	1	8

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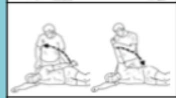
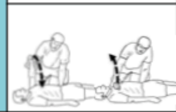
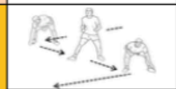
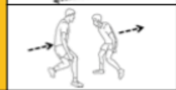
CRISP INJURY PREVENTION PROTOCOL -**PHASE 2**

		Exercise	Key Points	Sets	Reps
Shoulder Eccentrics		Internal/ External Rota-tion	• Elbow against side at 90 degrees • Offer 50% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
		Abduction / Adduction	• Lay on side with knees bent • Offer 50% resistance only • 4 seconds per movement • Movement finishes once arm points upwards • Repeat twice on each side	2 each arm	2 reps of 4 secs
		Flexion / Extension	• Lay on back, with the arm straight • Offer 50% resistance only • 4 seconds per movement • Movement finishes once arm is inline with body • Repeat twice on each side	2 each arm	2 reps of 4 secs
		Horizontal Flexion	• Lay on back, with the arm straight in front of shoulder • Arm is pushed across chest, then pulled to starting position • Offer 50% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
Mobility		Tall lunge walks	• Front knee over mid-foot • Reach upwards, extending onto tiptoes and bringing the front knee up in-line with the hip during transition	1	15m
		Squat to stand with thoracic rotations	• Feet shoulder width apart • Look forward and lift chest up during squat phase • Rotate torso both directions during squat phase	1	10
Landing / C.O.D		Side sway drill	• Double side step and reach to the ground • Finish in sideways lunge, • Repeat on both sides	2	15m
		Partner Mirroring	• Players stand ~3m apart • Retreating player mimics advancing players movement • Retreating player must maintain 3m gap	1	15m
Plyometrics		Kneeling 'faith-falls'	• Keep knee hip and shoulder aligned • Raise arms ready for 'catch', slightly wider than shoulders	1	10
		Split jumps	• Both knees flex to ~90 degrees during lunge • Front knee over mid foot • Rear knee does not contact ground • Jump as high as possible	1	10

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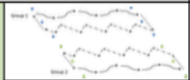
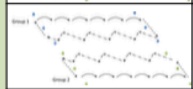
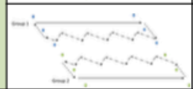
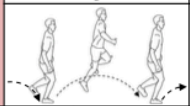
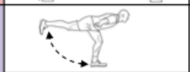
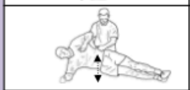
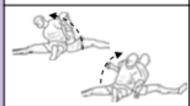
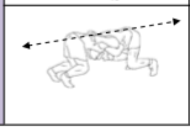
CRISP INJURY PREVENTION PROTOCOL -**PHASE 3**

PHASE 3		Exercise	Key Points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• 5m x 15m channels • Use full width channel • Head up looking forward • 50-70% Effort only	1	2
Preparation		**Stride-outs** (back skip on return)	• 5m x 15m channels • Max distance with each bound • Drive the knee up • 50-70% effort	1	2
Preparation		**2 point stance and accelerate** (back skip on return)	• 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 50-70% effort	1	2
Balance		**Single leg balance, eyes closed**	• Maintain well aligned upright posture • Maintain balance • Keep legs apart. • Keep eyes closed	1 each leg	30 secs
Balance		**Triple hop and stop**	• 3 successive hops for distance • 'Stick' landing on last hop • Then maintain balance for 4 seconds • Keep looking forwards	3 each leg	3 hops
Strength		**Hip airplanes**	• Focus on keeping the hips level and back leg straight • Maintain alignment from ankle to shoulder	1 each leg	5
Strength		**Side plank perturbation**	• Focus on alignment • Do not hitch / bend / twist at the hip. • Partner repeatedly pushes hip down	1 each side	20 secs
Strength		**Seated side pulls**	• Start with neutral back position • Legs in a wide straddle • One partner resists • Active partner pulls side ways	1 each side	5
Strength		**Scrum push**	• Keep the back straight • Have feet shoulder width apart. Feet should not move during exercise. • Aim to extend knees and push partner back, then swap roles.	1	8

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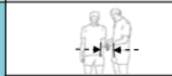
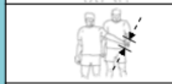
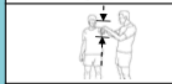
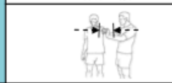
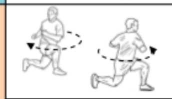
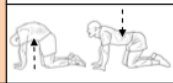
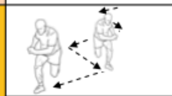
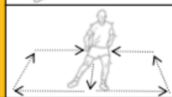
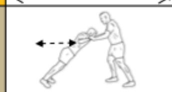
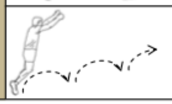
CRISP INJURY PREVENTION PROTOCOL -**PHASE 3**

		Exercise	Key Points	Sets	Reps
Shoulder Strength		**Internal / External Rotation**	• Keep elbow in contact with body at all times • Do NOT push too hard – only 50% effort	1 each arm	10 secs
Shoulder Strength		**Abduction / Adduction**	• Arm at 45 degrees to body • No movement should occur during the exercise • 60-70% effort only	1 each arm	10 secs
Shoulder Strength		**Flexion / Extension**	• Arm should be at 90 degrees to body facing forwards • No movement should occur during the exercise • 60-70 % effort only	1 each arm	10 secs
Shoulder Strength		**Horizontal Flexion**	• Arm should be at 90 degrees to body facing forwards • No movement should occur during the exercise • 60-70 % effort only	1 each arm	10 secs
Mobility		**Lunge Walk and twist**	• Lunge forward until back knee is near the ground but not touching • Hold position and rotate torso across lead leg • Repeat on opposite side.	1	15 m
Mobility		**Happy cat / Angry cat**	• On all fours with hands under shoulders and knees under hips • Players fully flex and then fully extend their backs	1	10
Landing / C.O.D		**Ice skaters**	• Bound a wide zig-zaged path • Focus on hard leg drive • Good arm drive • Aim for good alignment of knee over foot	2	15 m
Landing / C.O.D		**Figure 8 drill**	• Use quick feet • Head up facing forwards • Alternate legs • Land softly	1	5
Plyometrics		**Standing press-ups**	• Stand just over two arm lengths apart • Partners arms straight • Perform 10 press-ups	1	10
Plyometrics		**Triple Jumps (Fast)**	Jump as fast as possible • Minimise contact time with the ground • Use 'stiff' ankles • 'Stick' last landing	4	3 jumps

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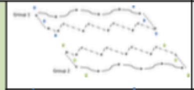
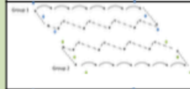
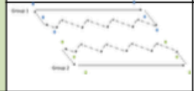
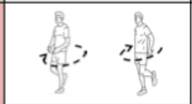
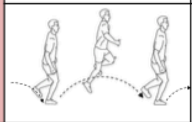
CRISP INJURY PREVENTION PROTOCOL -**PHASE 4**

PHASE 4		Exercise	Key Points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• 5m x 15m channels • Use full width channel • Head up looking forward • 50-70% Effort only	1	2
		**Stride-outs** (back skip on return)	• 5m x 15m channels • Max distance with each bound • Drive the knee up • 50-70% effort	1	2
		**2 point stance and accelerate** (back skip on return)	• 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 50-70% effort	1	2
Balance		**Single leg balance, eyes closed passing Object**	• Maintain well aligned upright posture • Maintain balance • Keep legs apart. • Keep eyes closed	1 each leg	30 secs
		**Weaving triple hop and stop**	• 3 successive diagonal hops, moving 20cm laterally while maximising distance • 'Stick' landing on last hop • Then maintain balance for 4 seconds • Keep looking forwards	3 each leg	3 hops
Strength		**Nordic hold**	• Knee, hip and shoulder in alignment • Partner holds ankles • Player leans forward to a position they can hold for	2 each person	10s hold
		**Side plank with leg raise**	• Focus on alignment • Do not hitch / bend / twist at the hip. • Raise and lower upper leg with control	1 each side	10 reps
		**Hand walk outs**	• Perform with minimal lateral movement of trunk and hips • Do not let hips drop during extended hold	1	5 walks
		**Reverse lunge with knee drive**	• Perform reverse lunge slow-ly • Drive knee up hard • Focus on knee alignment over toes during lunge	1	5 lunges

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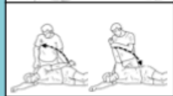
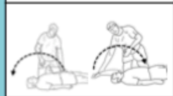
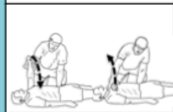
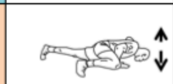
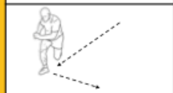
CRISP INJURY PREVENTION PROTOCOL -**PHASE 4**

		Exercise	Key Points	Sets	Reps
Shoulder Eccentrics		**Internal/ External Rota-tion**	• Elbow against side at 90 degrees • Offer 50% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Abduction / Adduction**	• Lay on side with knees bent • Offer 70% resistance only • 4 seconds per movement • Movement finishes once arm points upwards • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Flexion / Extension**	• Lay on back, with the arm straight • Offer 70% resistance only • 4 seconds per movement • Movement finishes once arm is inline with body • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Horizontal Flexion**	• Lay on back, with the arm straight in front of shoulder • Arm is pushed across chest, then pulled to starting position • Offer 70% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
Mobility		**Spiderman crawl and press**	• Keep low to the ground • Perform slowly • Knees outside of elbows.	1	15m
		**Prone chainsaw pulls**	• Reach as far as possible on each movement • Perform with control • Do not let the hips drop • Repeat both sides	1ea.	10
Landing / C.O.D		**Figure 8 bounds**	• Bound explosively • Vary direction of bound randomly • Minimise ground contact time • Focus on good knee alignment	1	10
		**Cut and sprint**	• Player decides when to cut Maximise the change in direction • Maintain knee alignment over lead foot • Accelerate hard out of 'cut'	2ea.	1 cut
Plyometrics		**Partner press-ups**	• Perform each press-up over 3-4seconds. • Hands should be in line with shoulders	1	10
		**Rebound tuck jumps**	• Jump explosively • Touch hands to shins • Minimise floor contact time be-tween jumps.	1	8

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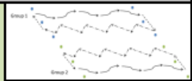
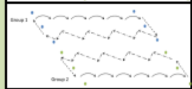
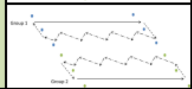
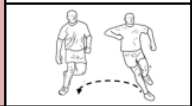
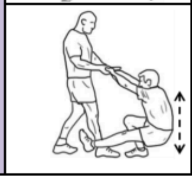
CRISP INJURY PREVENTION PROTOCOL -**PHASE 5**

PHASE 5		Exercise	Key Points	Sets	Reps
Preparation		**Swerve Runs** (back skip on re-turn)	• 5m x 15m channels • Use full width channel • Head up looking forward • 50-70% Effort only	1	2
		**Stride-outs** (back skip on return)	• 5m x 15m channels • Max distance with each bound • Drive the knee up • 50-70% effort	1	2
		**2 point stance and accelerate** (back skip on return)	• 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 50-70% effort	1	2
Balance		**Single leg balance, partner push**	• Maintain well aligned upright posture • Maintain balance • Keep legs apart. • Gently push partner	1 each leg	30 secs
		**Lateral hop and balance**	• Hop sideways about 1m • 'Stick' the landing • Then maintain balance for 4 seconds • Keep looking forwards	1 each leg	5 hops
Strength		**Bent hip Nordics**	• Hips bent to 30 degrees • Lower toward ground slowly • Use arms if necessary	1	5
		**Single leg side plank (static)**	• Focus on straight alignment of ankle, hip and shoulder • Do not hitch / bend / twist at the hip. • Repeat each side	1 each side	20 secs
		**Single leg, hand walk outs**	• Stand on one leg • Take weight on hands • Walk hand forwards as far as possible • Do not let hips or torso touch ground	1 each side	3
		**Partner as-sisted, pistol squats**	• Keep non active leg straight & off of ground • Squat until hip is at or below knee level • Partner can assist as necessary • Stance knee should track over mid-foot and toes • Perform slowly, with maximum control	1 each side	4

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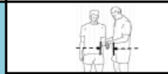
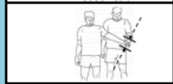
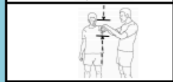
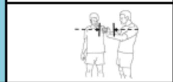
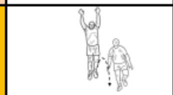
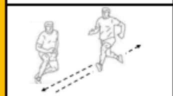
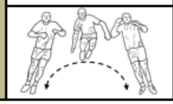
CRISP INJURY PREVENTION PROTOCOL -**PHASE 5**

		Exercise	Key Points	Sets	Reps
Shoulder Strength		**Internal / External Rotation**	• Keep elbow in contact with body at all times • Do NOT push too hard – only 50% effort	1 each arm	10 secs
		**Abduction / Adduction**	• Arm at 45 degrees to body • No movement should occur dur-ing the exercise • 60-70% effort only	1 each arm	10 secs
		**Flexion / Extension**	• Arm should be at 90 degrees to body facing forwards • No movement should occur dur-ing the exercise • 60-70 % effort only	1 each arm	10 secs
		**Horizontal Flexion**	• Arm should be at 90 degrees to body facing forwards • No movement should occur dur-ing the exercise • 60-70 % effort only	1 each arm	10 secs
Mobility		**Sumo squats**	• Complete with a wide base • Aim to squat until hips are at or below knee level • Maintain a neutral spine • Rotate and repeat	1	10
		**Supine scorpions**	• Lay on back • Swing leg up and across body toward opposite arm • Alternate leg each time	1	10
Landing / C.O.D		**High jump, single leg land and balance**	• Perform a maximal jump for height • Land on a single leg • Soft landing • Balance for 4 seconds & repeat	1 each side	5
		**Shuttle sprint**	• Over 15m, sprint maximally • Decelerate as fast as possible • Turn and sprint back • Turn once off of each leg	2	1
Plyometrics		**Kneeling faith'fall' and press-up**	• Start in tall kneeling • Knees, hips and shoulders in line • Fall forwards using arms to catch weight • Perform a press-up immediately	1	8
		**Lateral rebound tuck jumps**	• Jump laterally about 1m • Tuck knees toward chest • Try and touch shins • Immediately rebound and repeat, alternating jump direction	1	8

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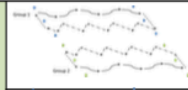
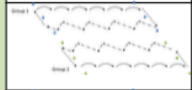
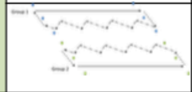
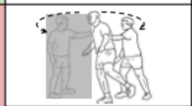
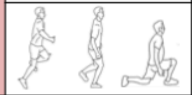
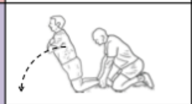
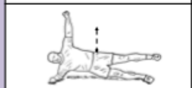
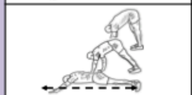
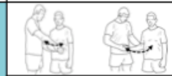
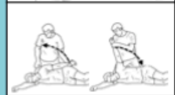
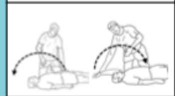
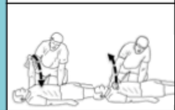
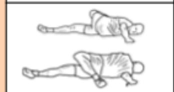
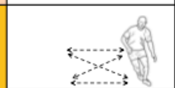
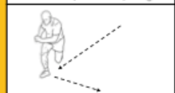
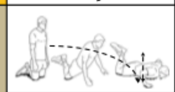
CRISP INJURY PREVENTION PROTOCOL -**PHASE 6**

PHASE 6		Exercise	Key Points	Sets	Reps
Preparation		**Swerve Runs** (back skip on return)	• 5m x 15m channels • Use full width channel • Head up looking forward • 50-70% Effort only	1	2
		**Stride-outs** (back skip on return)	• 5m x 15m channels • Max distance with each bound • Drive the knee up • 50-70% effort	1	2
		**2 point stance and accelerate** (back skip on return)	• 5m x 15m channels • Head up looking forward • Drive the arms • Quick feet • 50-70% effort	1	2
Balance		**Single leg balance, eyes closed partner push**	• Maintain balance • Keep legs apart. • Keep eyes closed • Partner moves around pushing from different positions	1 each leg	30 secs
		**Hop out, single leg reverse lunge**	• Hop out and 'stick' landing • Maintain balance and perform a reverse lunge	3 each leg	3 hops
Strength		**Full Nordic hamstring falls**	• Knee, hip and shoulder in alignment • Partner holds ankles • Player lowers body to floor slowly	5 each person	1
		**Single leg side plank pulses**	• Focus on alignment • Do not hitch / bend / twist at the hip. • Raise and lower hip 2-3 inches, keeping leg in air.	1 each side	10 reps
		**Hand walk outs (FAST)**	• Perform as fast as possible without loosing control • Do not let hips drop during movement	1	5 walks
		**Partner assisted, pistol squats (FAST)**	• Keep non active leg straight & off of ground • Squat until hip is at or below knee level • Partner can assist as necessary • Perform quickly, with maximum control	1	5 squats

For enquiries contact: Simon Roberts Tel: 01225 384531 Mob: 07890261228 Email rfu-crisp@bath.ac.uk Matthew Attwood Tel: 01225 385176 Mob: 07538634023

CRISP INJURY PREVENTION PROTOCOL -**PHASE 6**

		Exercise	Key Points	Sets	Reps
Shoulder Eccentrics		**Internal/ External Rotation**	• Elbow against side at 90 degrees • Offer 50% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Abduction / Adduction**	• Lay on side with knees bent • Offer 70% resistance only • 4 seconds per movement • Movement finishes once arm points upwards • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Flexion / Extension**	• Lay on back, with the arm straight • Offer 70% resistance only • 4 seconds per movement • Movement finishes once arm is inline with body • Repeat twice on each side	2 each arm	2 reps of 4 secs
		**Horizontal Flexion**	• Lay on back, with the arm straight in front of shoulder • Arm is pushed across chest, then pulled to starting position • Offer 70% resistance only • 4 seconds per movement • Repeat twice on each side	2 each arm	2 reps of 4 secs
Mobility		**Reverse Spiderman**	• Keep low to the ground as possible • Perform slowly travelling backwards • Knees outside of elbows.	1	15m
		**Prone scorpions**	• Lay on front • Swing leg back and across body towards opposite arm • Alternate leg each time	1ea.	10
Landing / C.O.D		**Figure 8 bounds**	• Bound explosively • Vary direction of bound randomly • Minimise ground contact time • Focus on good knee alignment	1	10
		**Cut and sprint**	• Run at 75% pace for 3-7m • Player decides when to cut • Maximise the change in direction • Accelerate hard out of 'cut'	2ea.	1 cut
Plyometrics		**Kneeling faith'fall' clap press-ups**	• Start in tall kneeling • Fall forwards, catching weight with arms • Immediately perform a clap	1	10
		**Rebound tuck Hops**	• Hop explosively upwards • Touch hands to shins • Minimise floor contact time between hops.	1 each side	5

For enquiries contact: Simon Roberts Tel: 01225 384531 Mob: 07890261228 Email rfu-crisp@bath.ac.uk Matthew Attwood Tel: 01225 385176 Mob: 07538634023

Appendix L. Interview questions – (Chapter 5)

Questions: Coach background and study inclusion

#	Questions	Expansions
1.1	Can you define your current role with the club for me?	
1.2	What skills and experience do you have that have 'qualified' you, formally or informally for your current role?	Previously a player, coaching qualifications, other qualifications of relevance?
1.3	How long have you had your current role with this club?	Previous to this club / role?
1.4	How did you first hear about the injury prevention warm up study?	Bath Uni, RDO, RFU, Physio other member?
1.5	Did you or did someone else get the team involved in the injury prevention warm up study?	Who was the first point of contact? Linked to 1.1
1.6	Why did you/your club get involved with this study?	
1.7	Do you feel a focus on injury prevention, such as is the intention of this study, is necessary as this level of rugby?	Why / why not?

Questions: Previous warm-up practice

#	Questions	Expansions
2.1	a) Previous to this season would your team normally do a warm up? b) why? c) How long would your team's warm up normally last?	
2.2	Giving as much detail as you can, what would the players have done to warm up prior to this season?	
2.3	Who would have normally taken / led this warm up?	Coach? Captain? Player with gym experience?
2.4	Did you incorporate injury prevention specific exercises prior to this study?	If yes, what? How often? Led by who? Whole squad or individual basis?
2.5	If yes, what injuries do you think this exercise(s) would have helped to prevent?	
IF TEAM HAS DROPPED OUT.		
2.6	Why did your team drop out?	
2.7	What have you done in your warm up since stopping your participation in the warm-up study	
2.8	Have you adopted/incorporated any of the exercises from the warm-up that you didn't do previously?	
2.9	If yes, what? Why?	

Questions: Roles and responsibilities within the club

#	Questions	Expansions
3.1	What has been your role with respect to the club's participation in the injury prevention warm-up study?	Warm up Leader, Delegator, Team registrar…..
3.2	Who in the team: Took the register? Marked off the coach's handbook?	How was this organised / decided / delegated?
3.3	If not yourself, who takes/leads the warm-up the team was provided? Why did they? What is their background / previous experience?	
3.4	What would happen if the person who led the warm-up was ill/away?	Someone else take it? What if they were away too? Were any further measures in place?
3.5	Which players have been regularly exposed to the warm up program?	#Aware of? # Familiar with? – on what basis #Exposed to?
3.6	Approximately how many players would be exposed on a normal training night to the: Group warm up? The Solo warm up	

Questions: Warm up delivery by CRISP Team

#	Questions	Expansions
4.1	Did you feel that the CRISP team delivered what you expected from your prior contact with the team during recruitment?	If not, what was different?
4.2	Did you feel the initial introduction and delivery of the warm-up was adequate? i.e., Did this initial delivery enable you to deliver the warm up with confidence from your first session?	Do you feel that further training would have been necessary; At phase one? At all phases? Just for the subsequent phases (2-6)?
4.3	Did you feel the subsequent delivery of the later phases was adequate to continue delivering subsequent warm-up phases with the same quality?	
4.4	Did you feel that the materials provided were clear?	
4.5	What materials did you use the most? Manuals Hand-outs Videos	Did you use the: Hand-outs Manuals Videos (Listed in anticipated order of most frequent)
4.6	Do you feel these resources could be improved in any way?	If yes, how? BE SPECIFIC
4.7	Do you feel that the resources alone would have empowered you to deliver the injury prevention warm up without having the visits from the CRISP team?	

Questions: Programme feedback

#	Questions	Expansions
5.1	To refresh your memory, I have the phase one exercises here. [Provide hand-out(s)]. Are there any aspects of this programme that you thought were better / more successful than others?	Best adherence, Why? Worst adherence, Why? Left out, Why?
5.2	Did you feel that the exercises were appropriately challenging for players at your club?	Were they too difficult / too easy? Appropriate progressions?
5.3	Look through the phases to refresh your memory and based on your experience using this warm-up would you change anything or keep it the same?	If so what? Why? What to put instead.
5.4	On average, how long do you think the programme took for your team to complete this warm-up?	Was this enough? Too much? Too little?
5.5	When within your training session would you implement the IPP Warm Up.	First thing. After touch. End?
5.6	Focusing on the admin tasks the club was asked to do, how much time do you feel the admin took?	Understandable time frame? Too much time?

Questions: Programme feedback (continued)

#	Questions	Expansions
5.7	When within your training session would the register be taken? …the warm-up log book be completed?	
5.8	If you felt the admin was too difficult / time consuming, do you have any suggestions on how it may be improved in the future?	
5.9	What if anything, affected your club completing the warm up?	Absent players / staff? Weather, Lights, Ground condition Day of the week Tuesday v Thursday (game prep)
5.10	Based on your team's use of the warm up, and your familiarity with the exercises, do you think the warm up led to an improvement in any particular skills or abilities?	If so what? How are you judging that? Performance attributes?
5.11	Do you think that the warm up did have an impact on the reduction of injuries within your team? If so, what injuries or otherwise how?	Region? Type of injury? How do you think this compares to previous years for your club?

Community Rugby Injury Surveillance Project (CRISP) – Warm-up practices and match Injury risk
2015-2016

Club participation information

Introduction
This information sheet introduces a research study of pre-training warm-up strategies and injury rates in rugby. We are currently recruiting clubs within RFU playing levels 3-9 to participate.

This Project is funded by the RFU on behalf of Community Rugby and coordinated by members of the Department for Health at the University of Bath.

Background
Rugby union has a relatively high injury incidence rate compared with other team sports. The RFU community rugby injury surveillance project (CRISP) has been running over the last six seasons, and has helped us to understand the frequency, type and causes of injury in the English community game many of which are sustained in the lower limb and potentially modifiable. We will continue to monitor injury patterns in the community game, but injury profile we have observed suggests that it is possible to reduce the risk of injury in community rugby.

Purpose
The aim of this study is to investigate the effect of rugby specific pre-training and match warm-up practices on injury rates in community rugby union.

What is involved in participating?

Delivery of a prescribed warm up during the season
We will work with you to identify a nominated person at the club (normally the coach or whoever delivers the team warm-up). We will visit you during the pre-season period to demonstrate a warm-up specifically designed for the demands of rugby. The pre-training warm-up lasts approximately 15 minutes and the pre-match warm-up lasts approximately 10 minutes. These should be carried out at the start of each training session and match during the season. Every six weeks during the season we will provide revised exercises that ensure variation and progressions to challenge the players.

We will provide all necessary resources
We will provide an information pack containing all the resources you will require for the season such as written guides, copies of injury forms, pre-paid envelopes etc. Video resources will also be available for the warm-up exercises but these will not require any specialist equipment which the club would have to purchase.

Injury surveillance

Player information
You will be asked to provide an up to date list of all 1st team squad players, with basic information such as their name, playing position, weight, height and date of birth.

Weekly report form
Each week we will ask you to complete a form which identifies who played in the first team and whether a prescribed warm-up was completed before each training session and match that week.

Time-loss injuries
We will work with you to identify a nominated person at the club (usually whoever deals with injured players) to complete a simple form to catalogue any match injury causing player to miss one match or more.

Player SMS
On Monday each week, consenting players will be sent one SMS message by the research team asking whether they sustained an injury in rugby related activity that week to which they will answer 'Yes' or 'No'. One follow up message will be sent if there the player does not reply to the initial message. If the answer 'Yes', they will be asked three further questions about the injury, each requiring single word answers. This will only involve contact between the players and the research team.

Full support will be available at all times during the season via telephone and email contact for any possible questions concerning any aspect of the study. Further information can be found on the Project web pages, the address of which can be found at the foot of this letter.

Your participation in this project is entirely voluntary but we hope that you can see its importance and wish to be involved. We understand that taking part will place an additional burden on your club but hopefully the benefits to your players and your club will make this worthwhile. You will also be making an extremely valuable contribution to the game of Rugby Union. At the end of the season, all participating clubs will receive feedback reports on how their injuries compare with clubs of a similar standard. Should you have any questions about participation in this project, I will happy to provide further details.

Dr Simon Roberts
Research Associate
Email: rfu-crisp@bath.ac.uk
Office: 01225 384531

RFU Community Rugby Injury Surveillance Project
http://go.bath.ac.uk/rfu-crisp

Appendix N. Participant information sheet – (Chapter 6)

RFU Community Injury Surveillance Project (CRISP) 2015/16
Player Information Sheet

An investigation of training warm-up practices and injury in rugby union players at English Community level clubs.

Principal Investigator: Matthew Attwood
Other investigators: Keith Stokes, Grant Trewartha, Simon Roberts, Carly McKay

You are invited to take part in a research study investigating training warm-up practises and injuries sustained during matches involving first team players registered with RFU English community clubs (levels) 3-9. The study is fully supported by the Rugby Football Union. Before deciding whether to take part, it is important that you understand why the study is being undertaken and whether it will affect you. Take time to the read the following information carefully; if there are any aspects of the study that you do not understand, please discuss them with a member of your medical team or contact us for further information. When you have read and fully understood the information and you wish to be included in the study, you will be asked to sign the attached Player Consent Form for the 2015/16 season. The Principal Investigator responsible for the study is Dr Simon Roberts at the University of Bath and he has been running the Community Rugby Injury Surveillance Project for seven years.

Background to the study
The aim of this study is to investigate training warm-up practices and injuries in English community club rugby. The information collected on warm-ups will allow the research team to understand more about how these are implemented in community rugby. The match play injury information will provide data collection which has been ongoing since 2008, allowing any changes in injury patterns over this time to be detected. Injury surveillance studies of this type provide data that help to monitor levels of injury risk and to develop injury prevention, treatment and rehabilitation programmes in rugby union.

What does the study involve?
The research team will provide coaching staff at your club with a prescribed warm-up protocol which they will be asked to deliver at the start of each training session during the 2015/16 season. Medical personnel at each club will record the details of all match injuries sustained by players in your club's 1st team causing the player to miss one match or more. If you take part you will be asked to respond to one SMS message per week, sent directly from the research team, to indicate whether you have sustained a rugby-related injury that week. This data will be analysed by researchers in the Department for Health at the University of Bath. The study will run for the entire 2015/16 season including pre-season.

Who is being asked to participate in the study?
All first team squad players in clubs participating in league competitions within RFU playing levels 3-9 are being invited to take part in the study.

Do players have to take part?
Participation in the study is voluntary. You do not have to take part in the study but the more players who take part, the more comprehensive the data will be. If you decide to take part you do not need to take any action. If you do not wish to take part you must sign the reverse side of this consent form to and return it to the member of your club coordinating the Project for the club. You are free to withdraw from the study by contacting us at any time without giving a reason.

What do I have to do?
You will be required to participate in the prescribed warm-up protocol which your club coaching team will deliver at the start of each club training session and match. Your club's medical staff will record the information about any injuries you sustain during match play. You will be asked to provide your mobile telephone number to the research team. Once per week during the rugby season you will be sent one SMS message by the research team asking whether you played in a match during the previous week. We ask that you answer this message with either a '1' (1st team), '2' (2nd team), '3' (3rd team) or 'x' (did not play). If you played you will be asked whether you sustained an injury. If you did, you will asked up to three further questions, all which will require one word answers.

Are there any risks from taking part?
You may be unaccustomed to some of the warm-up exercises but these will be simple to perform initially with the level of difficulty increasing as the season progresses.

Will information about my injuries be kept confidential?
In accordance with the Data Protection Act, we must obtain your permission to collect information about your injuries during the course of this study. All information collected in the study is recorded and stored anonymously using a player identification code on a database at the University of Bath.

For further information contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail: rfu-crisp@bath.ac.uk)

RFU Community Injury Surveillance Project (CRISP) 2015/16
Player Information Sheet

What will happen to the data obtained from the research study?
The data collected will be collated and analysed by researchers at the University of Bath in order to produce summary information about the incidence and nature of injuries and training practices in English community rugby. No personal references will be made in any material published or report.

Player consent

This study operates an 'opt-out' policy. ONLY SIGN AND RETURN THIS FORM IF YOU DO NOT WISH TO TAKE PART.

IF YOU WOULD TO TAKE PART:
If you have read and understood the player information sheet for the above study and had the opportunity to ask questions and wish to take part, you do not have to take any further action. This will allow doctors, physiotherapists and fitness/ conditioning staff to supply medical information to the University of Bath. Such information will only be used for research, statistical and other analysis purposes, and personal references shall not be made in any report or other published material. All the information provided on your injuries and training will be treated in strict confidence and will remain anonymous.

You have the right to withdraw from this study at any stage by signing and returning this form and will not be required to explain your reasons for withdrawing.

IF YOU DO NOT WISH TO TAKE PART:
If you have read and understood the player information sheet for this study and DO NOT WISH TO TAKE PART, please enter your name, date and signature below and return this form the club staff member responsible for the Project at your club. In doing so, none of your personal details will be provided by your club to the study team.

Name ____________________ Date ______________ Signature ________________

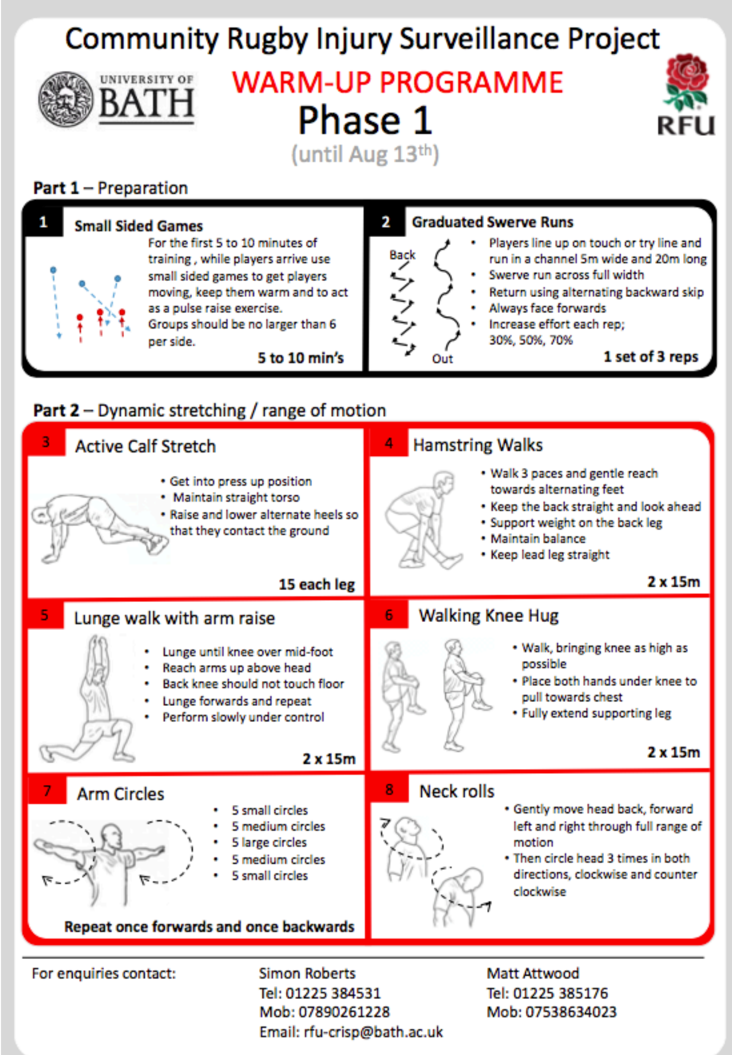
OFFICE USE ONLY

CLUB [ ]

PLAYER REGISTRATION NUMBER [| | | | | | |]

For further information contact Matthew Attwood, University of Bath. (Tel: 01225 384531; e-mail: rfu-crisp@bath.ac.uk)

Appendix *O*. The seven phases of the final control programme as provided to clubs during 2015/2016 – (Chapter 6)



Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 1

(until Aug 13th)

RFU

Part 1 – Preparation

1 **Small Sided Games**
For the first 5 to 10 minutes of training, while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.
5 to 10 min's

2 **Graduated Swerve Runs**
Back
Out
- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active Calf Stretch
- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

15 each leg

4 Hamstring Walks
- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

2 x 15m

5 Lunge walk with arm raise
- Lunge until knee over mid-foot
- Reach arms up above head
- Back knee should not touch floor
- Lunge forwards and repeat
- Perform slowly under control

2 x 15m

6 Walking Knee Hug
- Walk, bringing knee as high as possible
- Place both hands under knee to pull towards chest
- Fully extend supporting leg

2 x 15m

7 Arm Circles
- 5 small circles
- 5 medium circles
- 5 large circles
- 5 medium circles
- 5 small circles

Repeat once forwards and once backwards

8 Neck rolls
- Gently move head back, forward left and right through full range of motion
- Then circle head 3 times in both directions, clockwise and counter clockwise

For enquiries contact:
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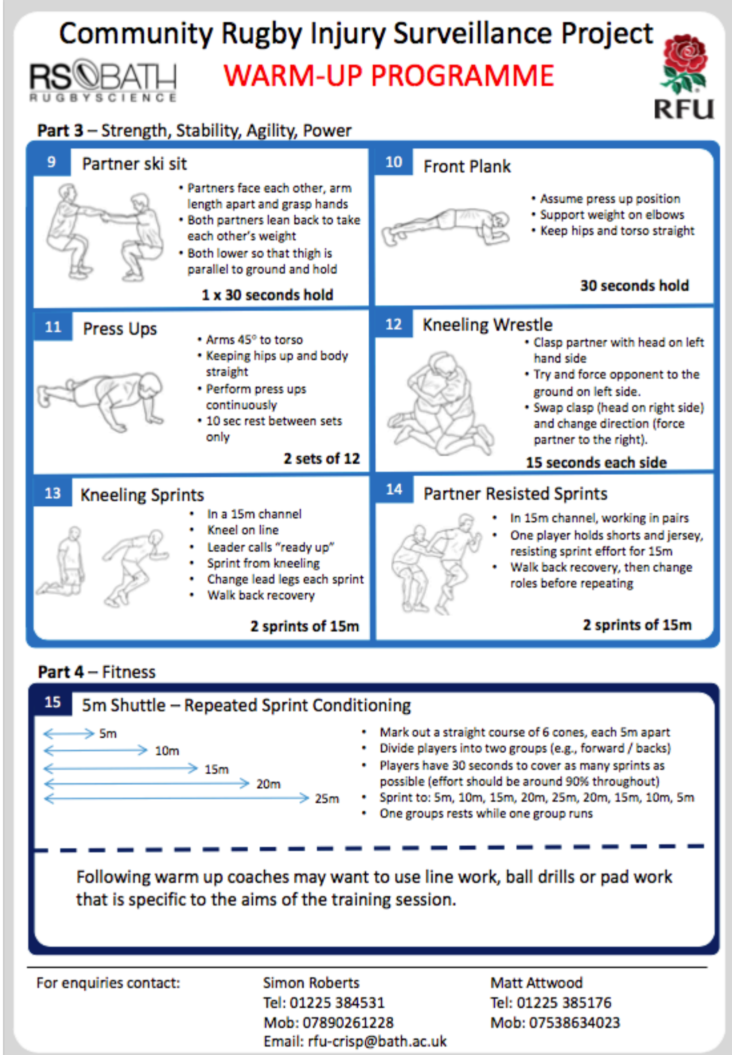
Tel: 01225 384531
Mob: 07890261228
Email: rfu-crisp@bath.ac.uk
Matt Attwood
Tel: 01225 385176
Mob: 07538634023



Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Partner ski sit
- Partners face each other, arm length apart and grasp hands
- Both partners lean back to take each other's weight
- Both lower so that thigh is parallel to ground and hold

1 x 30 seconds hold

10 Front Plank
- Assume press up position
- Support weight on elbows
- Keep hips and torso straight

30 seconds hold

11 Press Ups
- Arms 45° to torso
- Keeping hips up and body straight
- Perform press ups continuously
- 10 sec rest between sets only

2 sets of 12

12 Kneeling Wrestle
- Clasp partner with head on left hand side
- Try and force opponent to the ground on left side.
- Swap clasp (head on right side) and change direction (force partner to the right).

15 seconds each side

13 Kneeling Sprints
- In a 15m channel
- Kneel on line
- Leader calls "ready up"
- Sprint from kneeling
- Change lead legs each sprint
- Walk back recovery

2 sprints of 15m

14 Partner Resisted Sprints
- In 15m channel, working in pairs
- One player holds shorts and jersey, resisting sprint effort for 15m
- Walk back recovery, then change roles before repeating

2 sprints of 15m

Part 4 – Fitness

15 5m Shuttle – Repeated Sprint Conditioning
5m
10m
15m
20m
25m
- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work that is specific to the aims of the training session.

For enquiries contact:
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Matt Attwood
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Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 2

(18th Aug - Sep 24th)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active Calf Stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

2 x 15m

5 Lunge Walk & Twist

- Lunge until knee over mid-foot
- Rotate torso left and right
- Lunge forwards and repeat
- Perform slowly under control

2 x 15m

6 Trunk Aeroplane

- Stand with feet wider than shoulders
- Touch left foot with right hand
- Then right foot with left hand
- Keep both arms at full span throughout to rotate trunk

15 reps each side

7 Partner Pec' Stretch

- Partner 1 kneels with arms extended
- Partner 2 stand behind, pulling back partners 1's arms
- Partner 1 should feel stretch in chest
- Avoid excessive stretch (should not be uncomfortable)

10 second stretch per partner

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

For enquiries contact: Simon Roberts, Tel: 01225 384531, Mob: 07890261228, Email: rfu-crisp@bath.ac.uk; Matt Attwood, Tel: 01225 385176, Mob: 07538634023

Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Partner Deep Squats

- Partners face each other and grasp hands
- Both partners lean back to take each other's weight
- Both lower so backside is below knees, then return again to standing

5 repetitions

10 Trunk stability

- Partner 1 kneels down facing partner 2 (standing)
- Partner 2 supports 1with hands
- Partner 2 takes away alternate hands and 2 maintains position

30 seconds work each

11 Partner Pull Ups

- Partner 1 lies down on back
- Partner 2 stands over in a strong squat
- Partner 1 grasps partner 2's hands
- Partner 2 tucks elbows into body
- Partner 1 performs a pull up
- Partner 2 stays stationary

2 sets of 12

12 Crunches

- Lay flat, arms above head and legs straight
- Simultaneously lower arms and raise legs
- Touch ankles with hands and return to start position
- Perform slowly under control

25 repetitions

13 Laying Sprints

- In a 15m channel
- Lay prone on line
- Captain calls "ready up"
- Sprint from laying position
- Change lead legs each sprint
- Walk back recovery

2 sprints of 15m

14 Hold & Release Sprints

- Partner 2 holds onto Partner 1's waist
- Partner 1 starts sprinting while resisted over the first 5m
- After 5m partner 2 releases and partner sprints over the next 15m

2 x 5 m resist and 15m sprint

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work that is specific to the aims of the training session.

For enquiries contact: Simon Roberts, Tel: 01225 384531, Mob: 07890261228, Email: rfu-crisp@bath.ac.uk; Matt Attwood, Tel: 01225 385176, Mob: 07538634023

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 3

(29th Sep – 5th Nov)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active Calf Stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

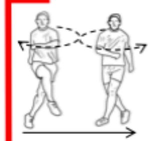
2 x 15m

5 Lunge & Knee Drive

- Step forward into lunge
- Back knee does not contact ground
- Drive off front foot
- Bring rear knee as high
- Step forward into lunge
- Repeat movement, raising same knee

2 x 15m

6 Carioca



- Jogging sideways, cross hind leg over lead leg, then repeat crossing hind leg behind lead leg
- While lower body rotates one way, twist trunk in the opposite direction

2 x 15m

7 Arm Circles

- 5 small circles
- 5 medium circles
- 5 large circles
- 5 medium circles
- 5 small circles

Repeat once forwards and once backwards

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

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Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Back to Back Squats

- Partners stand back to back, touching
- Both take a small step away and lean into each other
- Both lower so thigh is parallel to ground
- Return again to standing

1 set of 20

10 Crouching Stability Push

- Eyes looking forwards
- Feet wide
- Flat back
- Head looking up
- Partners push each other at various points
- Both aim to remain stable

30 seconds

11 Bear Crawl

- Crouch on all fours
- Back straight, low and parallel with ground
- 'Crawl' forward, extending arm
- Bring opposite knee forward to touch same side elbow
- Keep back low throughout

15m

12 V Sit Crunches

- Lay flat, arms above head and legs straight
- Simultaneously lower arms and raise legs
- Touch ankles with hands and return to start position

25 repetitions

13 Sprint Stops

- Players accelerate maximally over 10m then must come to a complete stop within 2 m
- Walk back to start

2 sprints of 12m

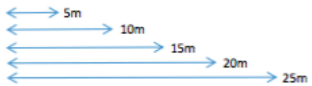
14 Shadow Sprints

- Partners 1 and 2 stand side by side
- Over 20m, partner 1 accelerates, decelerates randomly to 'lose' partner 2
- Partner 2 to stay within 2m of partner 1
- Partner 1 to change direction up to 5 times. Only run forwards and backwards

One lead for each partner over 20m

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning



- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- 30 seconds to cover as many sprints as possible
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work specific to the session to follow.

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Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME
Phase 4

RFU

(10th Nov – 5th Jan)

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active Calf Stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

2 x 15m

5 Sumo Squats

- Stand with feet wider than shoulder width apart
- Squat with knees bent to 90 degrees.
- Return to standing, then pivots on one leg to turn to face opposite direction
- Repeat the squat movement

10 repetitions

6 Prone Hip Stretch

- Get into press up position
- Bring right foot to as close to left hand as possible
- Gently lower hips towards ground
- Return foot to start and repeat on opposite side

5 repetitions each leg

7 Partner Pec' Stretch

- Partner 1 kneels with arms extended
- Partner 2 stand behind, pulling back partners 1's arms
- Partner 1 should feel stretch in chest
- Avoid excessive stretch (should not be uncomfortable)

10 second stretch per partner

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

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Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Full Squats

- Feet hips width apart
- Neutral spine
- Cross arms in front of chest
- Squat as low as possible
- Don't pause but move continuously throughout

1 set of 20

10 Partner Push Up Step Ups

- Partners adopt press up position
- Partner 1 side on to partner 2 to create a T shape
- Partner 2 slowly performs step-ups by marching with both hands up onto the back of partner 1 and down again

10 repetitions each

11 Wide Arm Press Ups

- Arms wider than shoulders
- Keeping hips up and body straight
- Perform press ups continuously
- 10 sec rest between sets only

2 sets of 20

12 Squat Thrusts

- Crouch on all fours
- In one movement, bring feet forward
- Land as close to hands as possible
- Return feet to start and repeat

20 repetitions

13 Graduated Sprints

- Players run over 25m, making sudden increases in speed at 5, 10 and 15m
- Start at 50% (0-5m)
- Finish at maximum pace

2 sprints of 25m

14 Sprint – STOP -Sprint

- Sprint for 10 m then stop within 2 m before sprinting another 10 m
- Player must come to a complete stop between sprints
- Emphasise fast feet

2 sprints of 22m

Part 4 – Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m 10m 15m 20m 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work specific to the session to follow.

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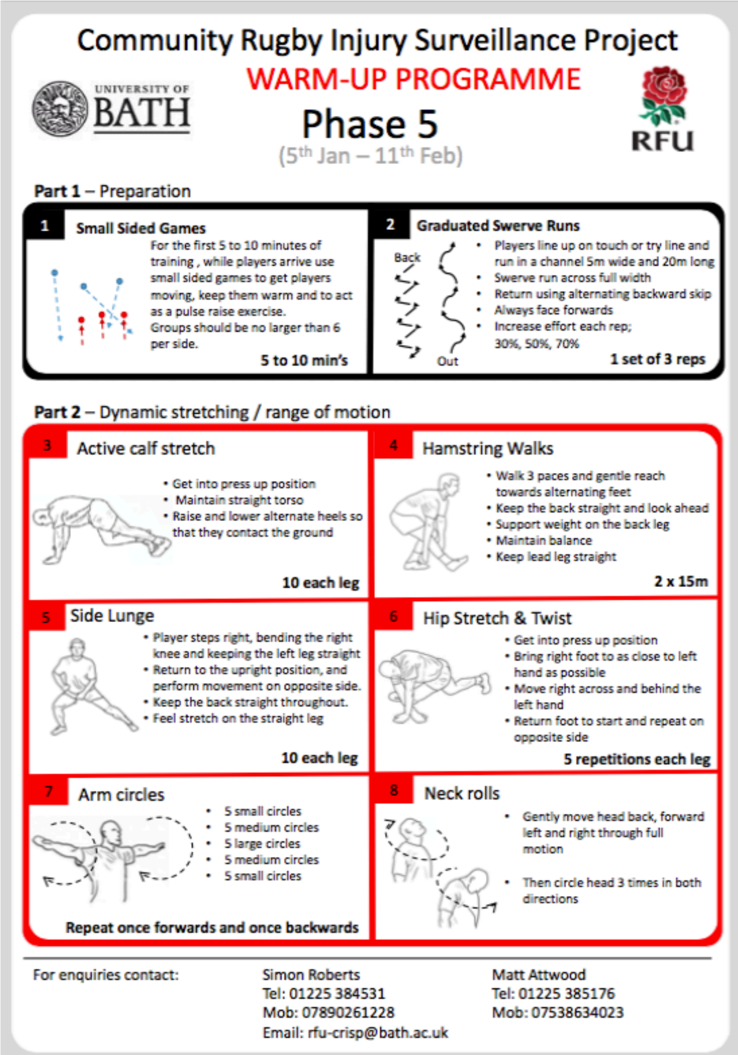

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 5

(5th Jan – 11th Feb)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active calf stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

2 x 15m

5 Side Lunge

- Player steps right, bending the right knee and keeping the left leg straight
- Return to the upright position, and perform movement on opposite side.
- Keep the back straight throughout.
- Feel stretch on the straight leg

10 each leg

6 Hip Stretch & Twist

- Get into press up position
- Bring right foot to as close to left hand as possible
- Move right across and behind the left hand
- Return foot to start and repeat on opposite side

5 repetitions each leg

7 Arm circles

- 5 small circles
- 5 medium circles
- 5 large circles
- 5 medium circles
- 5 small circles

Repeat once forwards and once backwards

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

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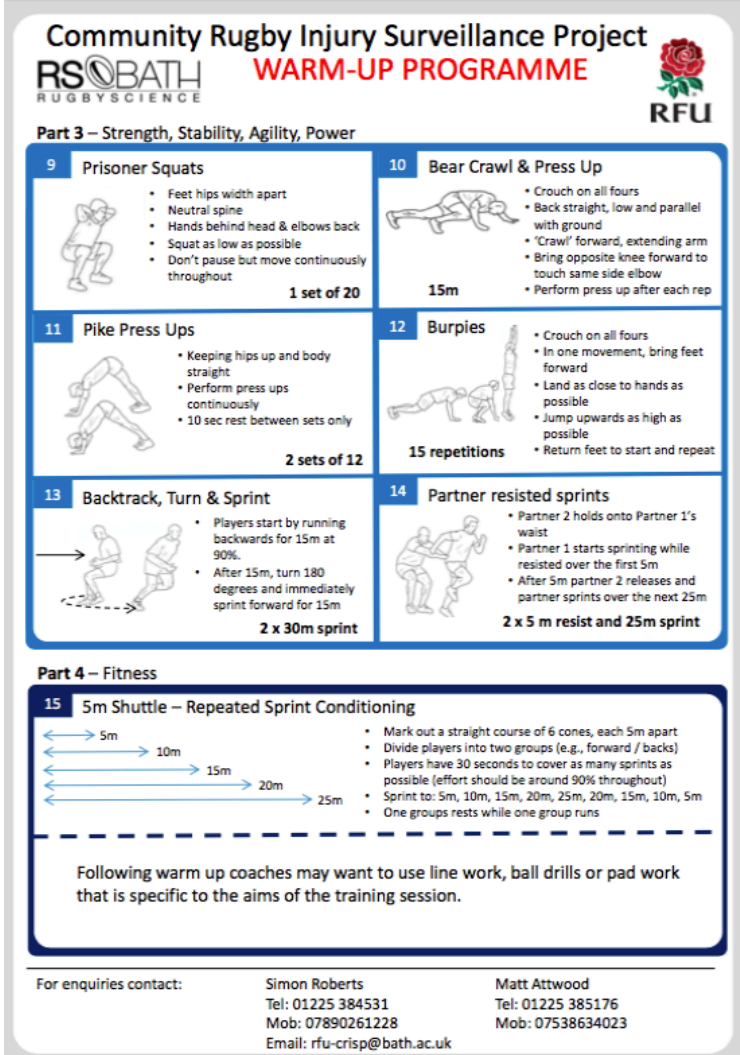

Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Prisoner Squats

- Feet hips width apart
- Neutral spine
- Hands behind head & elbows back
- Squat as low as possible
- Don't pause but move continuously throughout

1 set of 20

10 Bear Crawl & Press Up

- Crouch on all fours
- Back straight, low and parallel with ground
- 'Crawl' forward, extending arm
- Bring opposite knee forward to touch same side elbow
- Perform press up after each rep

15m

11 Pike Press Ups

- Keeping hips up and body straight
- Perform press ups continuously
- 10 sec rest between sets only

2 sets of 12

12 Burpies

- Crouch on all fours
- In one movement, bring feet forward
- Land as close to hands as possible
- Jump upwards as high as possible
- Return feet to start and repeat

15 repetitions

13 Backtrack, Turn & Sprint

- Players start by running backwards for 15m at 90%.
- After 15m, turn 180 degrees and immediately sprint forward for 15m

2 x 30m sprint

14 Partner resisted sprints

- Partner 2 holds onto Partner 1's waist
- Partner 1 starts sprinting while resisted over the first 5m
- After 5m partner 2 releases and partner sprints over the next 25m

2 x 5 m resist and 25m sprint

Part 4 – Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work that is specific to the aims of the training session.

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Community Rugby Injury Surveillance Project

WARM-UP PROGRAMME

UNIVERSITY OF BATH

RFU

Phase 6

(16th Feb – 24th Mar)

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active Calf Stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

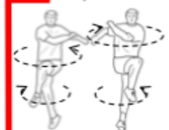
2 x 15m

5 High Knee Reverse Lunge

- Raise one knee as high as possible
- Lower leg, landing foot behind opposite foot
- Lunge onto back knee (knee does not contact ground)
- Repeat movement, raising same knee

10 each leg

6 Skip & Twist



- High skip with a counter movement or upper and lower body
- Aim for maximum rotation
- Keep the knee high
- Stay high on the balls of the feet.

2 x 15m

7 Partner Pec' Stretch

- Partner 1 kneels with arms extended
- Partner 2 stand behind, pulling back partners 1's arms
- Partner 1 should feel stretch in chest
- Avoid excessive stretch (should not be uncomfortable)

15 second stretch per partner

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

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Community Rugby Injury Surveillance Project

WARM-UP PROGRAMME

RS BATH RUGBY SCIENCE

RFU

Part 3 – Strength, Stability, Agility, Power

9 Squat Jumps

- Feet hips width apart
- Neutral spine
- Hands folded across chest
- Squat as low as possible
- Jump high as possible
- Land and repeat movement continuously throughout

10 repetitions

10 Around The World Piggyback

- Partner 1 adopts a stable position squatting position with a straight back
- Partner 2 climbs onto partner 1's back as if piggybacking.
- Partner 2 moves around the torso of partner 1 without touching the ground.
- Final position is back to the piggyback

1 go each

11 Clap Press Ups

- Arms 45° to torso
- Keeping hips up and body straight
- Perform press ups continuously
- Push maximally and clap hands before landing
- 10 sec rest between sets only

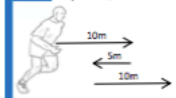
2 sets of 12

12 Star Jump Burpies

- Crouch on all fours
- In one movement, bring feet forward
- Land as close to hands as possible
- Jump upwards as high as possible in a star jump
- Return feet to start and repeat

20 repetitions

13 Sprint, Backtrack, Sprint



- Sprint forwards for 10 m
- Then stopping immediately, run backwards for 10m
- Then immediately sprint forwards for 20m

2 sprints of 20m

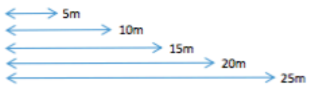
14 Shadow Sprints

- Partners 1 and 2 stand side by side
- Over 20m, partner 1 accelerates, decelerates randomly to 'lose' partner 2
- Partner 2 to stay within 2m of partner 1
- Partner 1 to change direction up to 8 times. Only run forwards and backwards

One lead for each partner over 20m

Part 4 – Fitness

15 5m Shuttle – Repeated Sprint Conditioning



- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

Following warm up coaches may want to use line work, ball drills or pad work that is specific to the aims of the training session.

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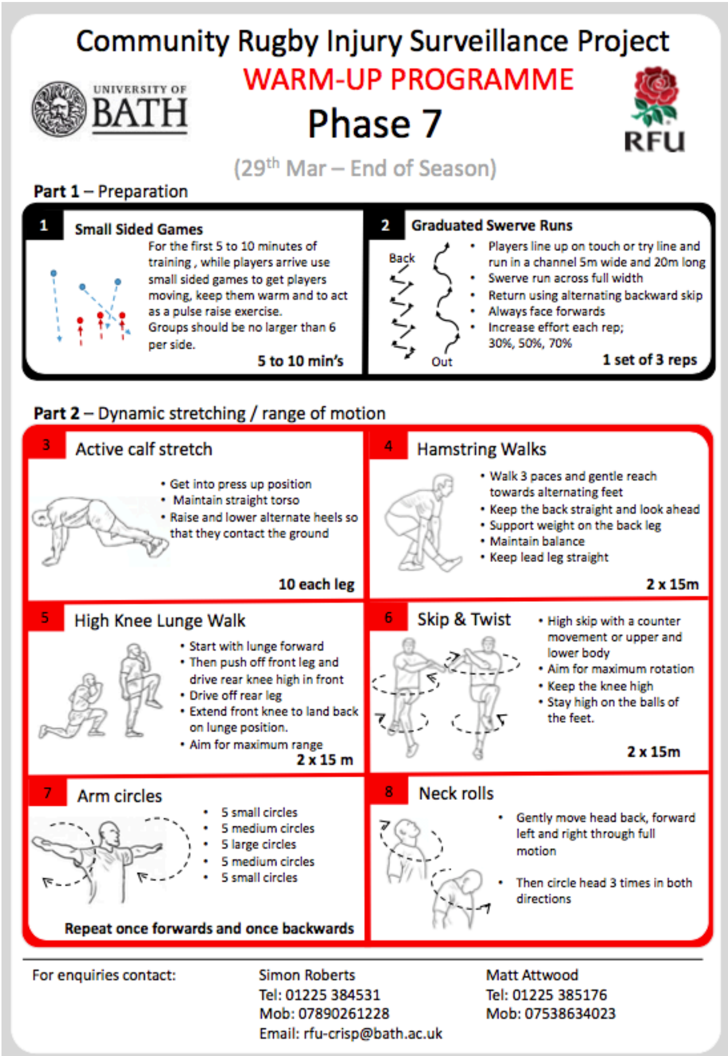

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 7

RFU

(29th Mar – End of Season)

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Dynamic stretching / range of motion

3 Active calf stretch

- Get into press up position
- Maintain straight torso
- Raise and lower alternate heels so that they contact the ground

10 each leg

4 Hamstring Walks

- Walk 3 paces and gentle reach towards alternating feet
- Keep the back straight and look ahead
- Support weight on the back leg
- Maintain balance
- Keep lead leg straight

2 x 15m

5 High Knee Lunge Walk

- Start with lunge forward
- Then push off front leg and drive rear knee high in front
- Drive off rear leg
- Extend front knee to land back on lunge position.
- Aim for maximum range

2 x 15 m

6 Skip & Twist

- High skip with a counter movement or upper and lower body
- Aim for maximum rotation
- Keep the knee high
- Stay high on the balls of the feet.

2 x 15m

7 Arm circles

- 5 small circles
- 5 medium circles
- 5 large circles
- 5 medium circles
- 5 small circles

Repeat once forwards and once backwards

8 Neck rolls

- Gently move head back, forward left and right through full motion
- Then circle head 3 times in both directions

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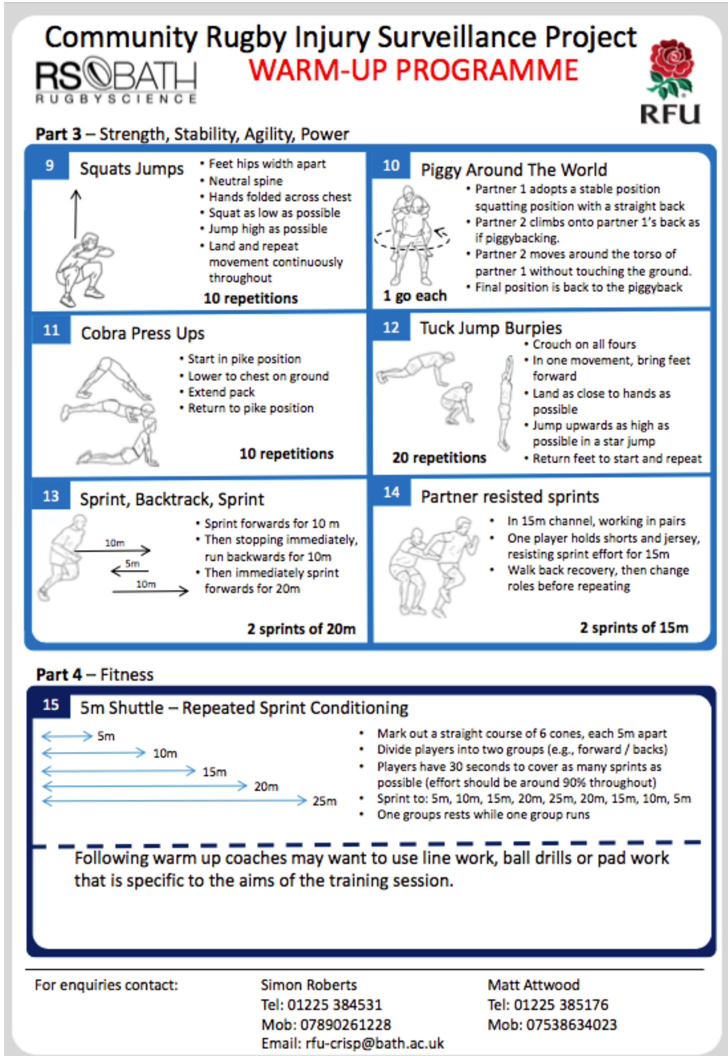

Community Rugby Injury Surveillance Project

RS BATH RUGBYSCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Squats Jumps

- Feet hips width apart
- Neutral spine
- Hands folded across chest
- Squat as low as possible
- Jump high as possible
- Land and repeat movement continuously throughout

10 repetitions

10 Piggy Around The World

- Partner 1 adopts a stable position squatting position with a straight back
- Partner 2 climbs onto partner 1's back as if piggybacking.
- Partner 2 moves around the torso of partner 1 without touching the ground.
- Final position is back to the piggyback

1 go each

11 Cobra Press Ups

- Start in pike position
- Lower to chest on ground
- Extend pack
- Return to pike position

10 repetitions

12 Tuck Jump Burpies

- Crouch on all fours
- In one movement, bring feet forward
- Land as close to hands as possible
- Jump upwards as high as possible in a star jump
- Return feet to start and repeat

20 repetitions

13 Sprint, Backtrack, Sprint

10m / 5m / 10m

- Sprint forwards for 10 m
- Then stopping immediately, run backwards for 10m
- Then immediately sprint forwards for 20m

2 sprints of 20m

14 Partner resisted sprints

- In 15m channel, working in pairs
- One player holds shorts and jersey, resisting sprint effort for 15m
- Walk back recovery, then change roles before repeating

2 sprints of 15m

Part 4 – Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Players have 30 seconds to cover as many sprints as possible (effort should be around 90% throughout)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups rests while one group runs

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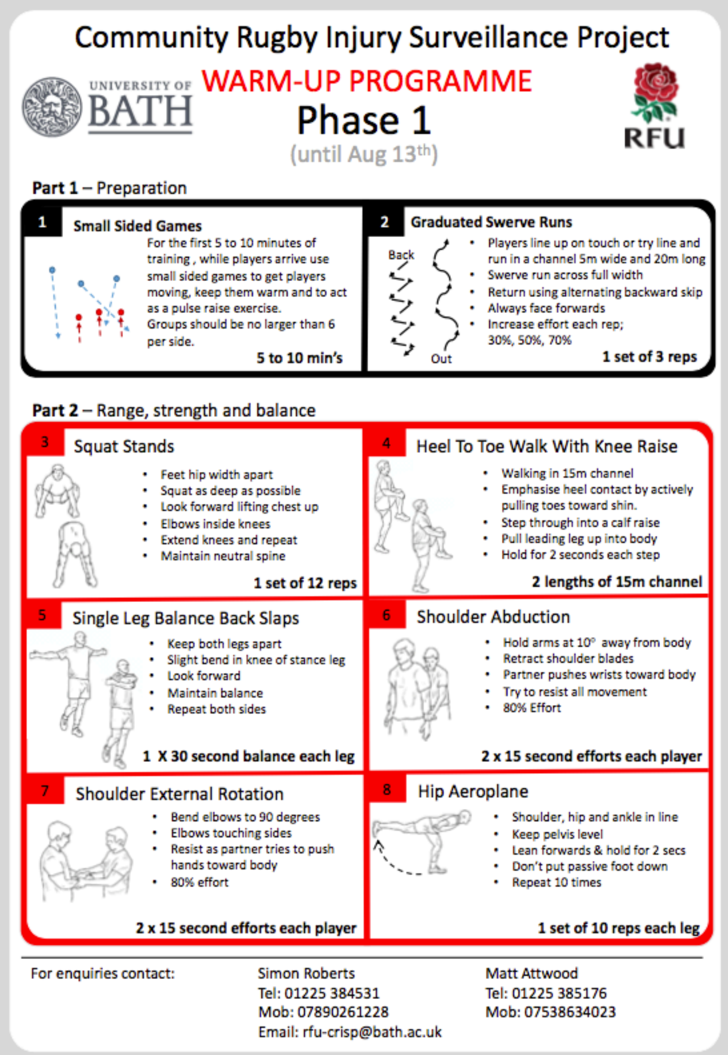
Appendix P.The seven phases of the final intervention programme as provided to clubs during the 2015/2016 – (Chapter 6)



Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 1

(until Aug 13th)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Squat Stands

- Feet hip width apart
- Squat as deep as possible
- Look forward lifting chest up
- Elbows inside knees
- Extend knees and repeat
- Maintain neutral spine

1 set of 12 reps

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Back Slaps

- Keep both legs apart
- Slight bend in knee of stance leg
- Look forward
- Maintain balance
- Repeat both sides

1 X 30 second balance each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Hip Aeroplane

- Shoulder, hip and ankle in line
- Keep pelvis level
- Lean forwards & hold for 2 secs
- Don't put passive foot down
- Repeat 10 times

1 set of 10 reps each leg

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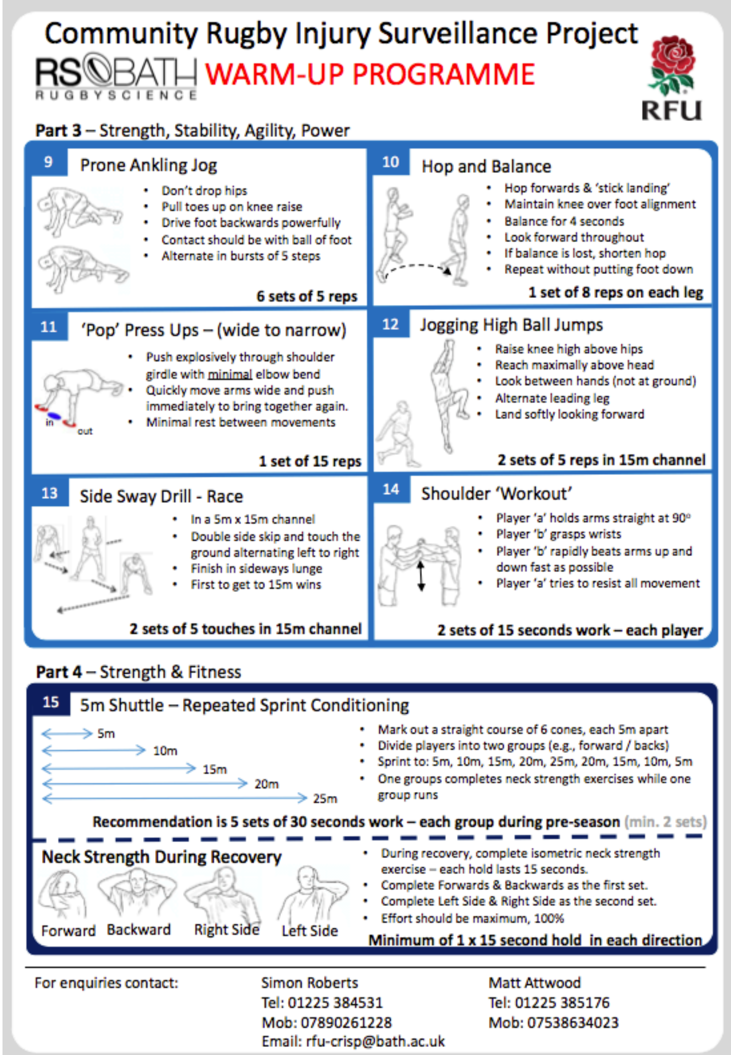


Community Rugby Injury Surveillance Project

RSBATH RUGBYSCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Prone Ankling Jog

- Don't drop hips
- Pull toes up on knee raise
- Drive foot backwards powerfully
- Contact should be with ball of foot
- Alternate in bursts of 5 steps

6 sets of 5 reps

10 Hop and Balance

- Hop forwards & 'stick landing'
- Maintain knee over foot alignment
- Balance for 4 seconds
- Look forward throughout
- If balance is lost, shorten hop
- Repeat without putting foot down

1 set of 8 reps on each leg

11 'Pop' Press Ups – (wide to narrow)

in / out

- Push explosively through shoulder girdle with minimal elbow bend
- Quickly move arms wide and push immediately to bring together again.
- Minimal rest between movements

1 set of 15 reps

12 Jogging High Ball Jumps

- Raise knee high above hips
- Reach maximally above head
- Look between hands (not at ground)
- Alternate leading leg
- Land softly looking forward

2 sets of 5 reps in 15m channel

13 Side Sway Drill - Race

- In a 5m x 15m channel
- Double side skip and touch the ground alternating left to right
- Finish in sideways lunge
- First to get to 15m wins

2 sets of 5 touches in 15m channel

14 Shoulder 'Workout'

- Player 'a' holds arms straight at 90°
- Player 'b' grasps wrists
- Player 'b' rapidly beats arms up and down fast as possible
- Player 'a' tries to resist all movement

2 sets of 15 seconds work – each player

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

Recommendation is 5 sets of 30 seconds work – each group during pre-season (min. 2 sets)

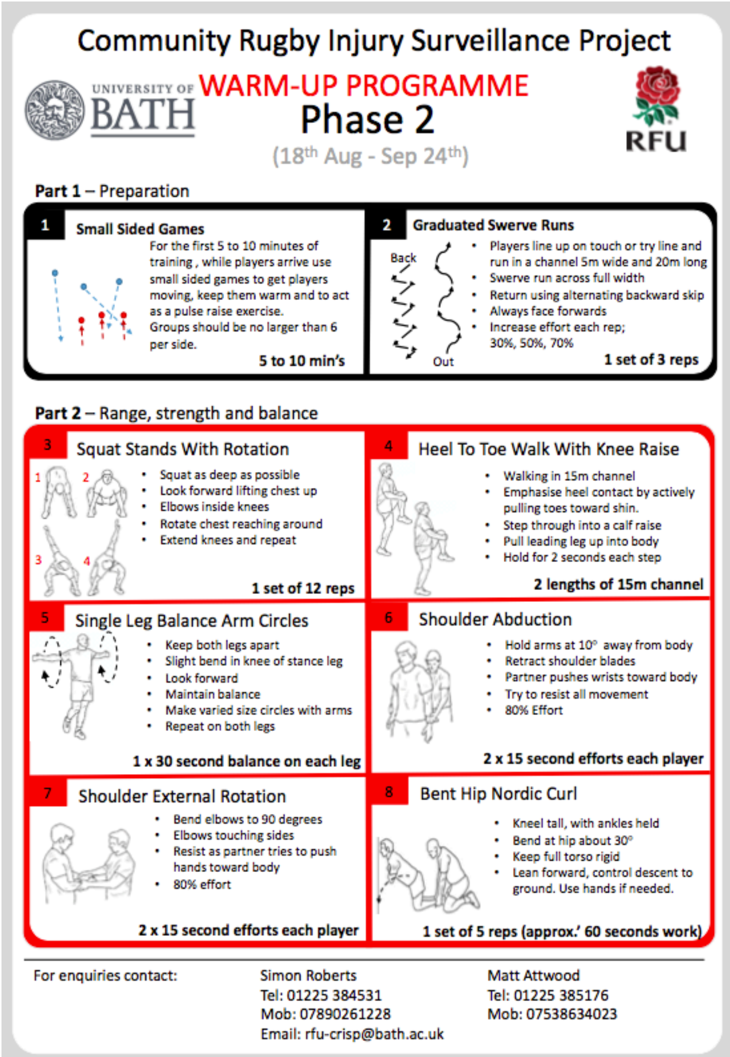
Neck Strength During Recovery

Forward / Backward / Right Side / Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

For enquiries contact: Simon Roberts Tel: 01225 384531 Mob: 07890261228 Email: rfu-crisp@bath.ac.uk Matt Attwood Tel: 01225 385176 Mob: 07538634023



Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 2

(18th Aug - Sep 24th)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise. Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Squat Stands With Rotation

- Squat as deep as possible
- Look forward lifting chest up
- Elbows inside knees
- Rotate chest reaching around
- Extend knees and repeat

1 set of 12 reps

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Arm Circles

- Keep both legs apart
- Slight bend in knee of stance leg
- Look forward
- Maintain balance
- Make varied size circles with arms
- Repeat on both legs

1 x 30 second balance on each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Bent Hip Nordic Curl

- Kneel tall, with ankles held
- Bend at hip about 30°
- Keep full torso rigid
- Lean forward, control descent to ground. Use hands if needed.

1 set of 5 reps (approx.' 60 seconds work)

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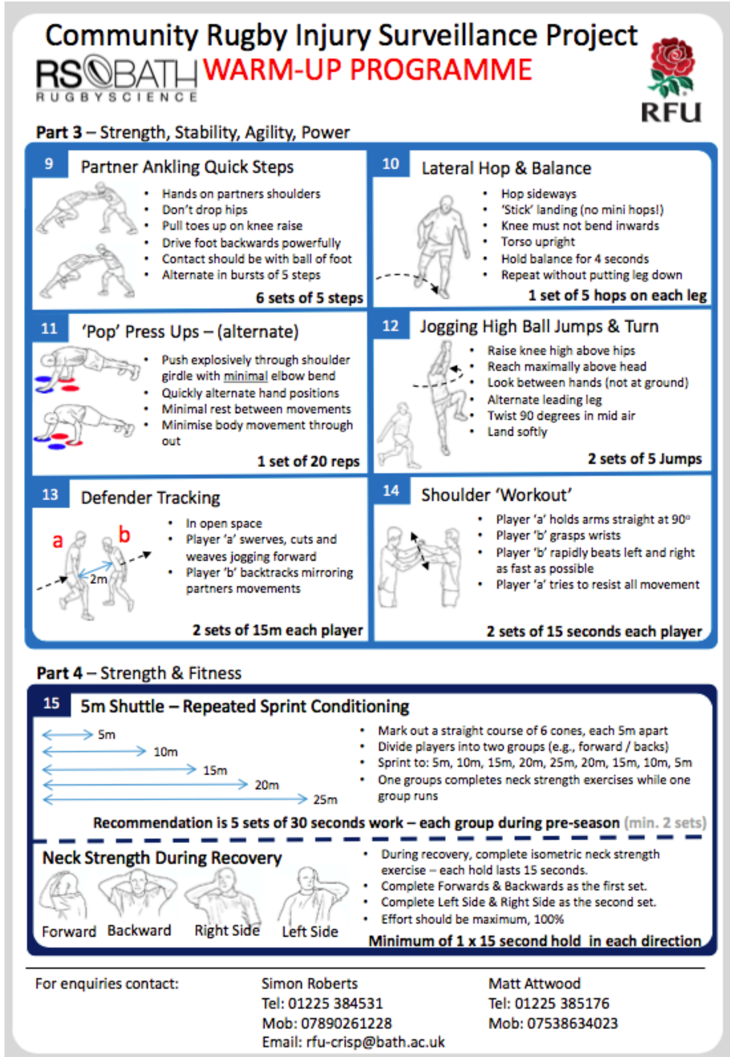

Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Partner Ankling Quick Steps

- Hands on partners shoulders
- Don't drop hips
- Pull toes up on knee raise
- Drive foot backwards powerfully
- Contact should be with ball of foot
- Alternate in bursts of 5 steps

6 sets of 5 steps

10 Lateral Hop & Balance

- Hop sideways
- 'Stick' landing (no mini hops!)
- Knee must not bend inwards
- Torso upright
- Hold balance for 4 seconds
- Repeat without putting leg down

1 set of 5 hops on each leg

11 'Pop' Press Ups – (alternate)

- Push explosively through shoulder girdle with minimal elbow bend
- Quickly alternate hand positions
- Minimal rest between movements
- Minimise body movement through out

1 set of 20 reps

12 Jogging High Ball Jumps & Turn

- Raise knee high above hips
- Reach maximally above head
- Look between hands (not at ground)
- Alternate leading leg
- Twist 90 degrees in mid air
- Land softly

2 sets of 5 Jumps

13 Defender Tracking

a / b / 2m

- In open space
- Player 'a' swerves, cuts and weaves jogging forward
- Player 'b' backtracks mirroring partners movements

2 sets of 15m each player

14 Shoulder 'Workout'

- Player 'a' holds arms straight at 90°
- Player 'b' grasps wrists
- Player 'b' rapidly beats left and right as fast as possible
- Player 'a' tries to resist all movement

2 sets of 15 seconds each player

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

Recommendation is 5 sets of 30 seconds work – each group during pre-season (min. 2 sets)

Neck Strength During Recovery

Forward / Backward / Right Side / Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

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Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 3

(29th Sep – 5th Nov)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Lunge Reach

- In a 15m channel
- Lunge forwards reaching arms up above head
- Stretch through groin of rear leg
- Rear knee does not touch ground

2 lengths of 15m channel

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Eyes Closed

- Balance on a single leg
- Legs must not touch
- Balance for 30 seconds
- **Eyes remain closed**
- Focus on ankle, knee and hip alignment

1 x 30 second effort each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Bent Hip Nordic Curl

- Kneel tall, with ankles held
- Bend at hip about 30°
- Keep full torso rigid
- Lean forward, control descent to ground. Use hands if needed.

1 set of 8 reps (approx.' 80 seconds work)

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Community Rugby Injury Surveillance Project

RSBATH RUGBYSCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Stiff Knee Ankle Bounds

- Keep knees and torso 'stiff'
- Little arm movement
- Bound through ankles
- Pull toes toward shin through jump
- Push explosively through ball of foot during ground contact
- Walk back recovery

2 lengths of 15m channel

10 Double Hop & Stop

- Hop forwards two times
- 'Stick' final landing
- Balance for 4 seconds
- Focus on knee staying over toes
- If balance is lost, shorten hops
- Keep torso upright

2 lengths of 15m channel

11 'Pop' Press Ups – (near - far)

- Push explosively through shoulder girdle with minimal elbow bend
- Quickly alternate hand positions
- Minimal rest between movements
- Minimise body movement through out

1 set of 20 reps

12 Lunge Jumps

- Jump powerfully, driving arms up
- Hind knee should not touch floor
- Both knees at 90° during lunge
- Knees over toes during lunge
- Torso upright throughout

1 sets of 10 reps

13 Figure 8 Drill

- Using imaginary 2m x 1m grid
- Always face forwards
- Skip laterally, run forwards and backwards
- Complete as many figure 8 as possible

1 x 30 second maximal effort

14 Shoulder 'Workout' (in pairs)

- Legs straight throughout
- Walk hands out as far as possible
- Don't allow trunk/hips to drop
- Out and in = 1 rep
- In pairs race to 5 reps
- 15 seconds rest between sets

2 sets of 5 reps

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

2 sets of 30 seconds work – each group

Neck Strength During Recovery

Forward / Backward / Right Side / Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

1 x 15 second hold in each direction

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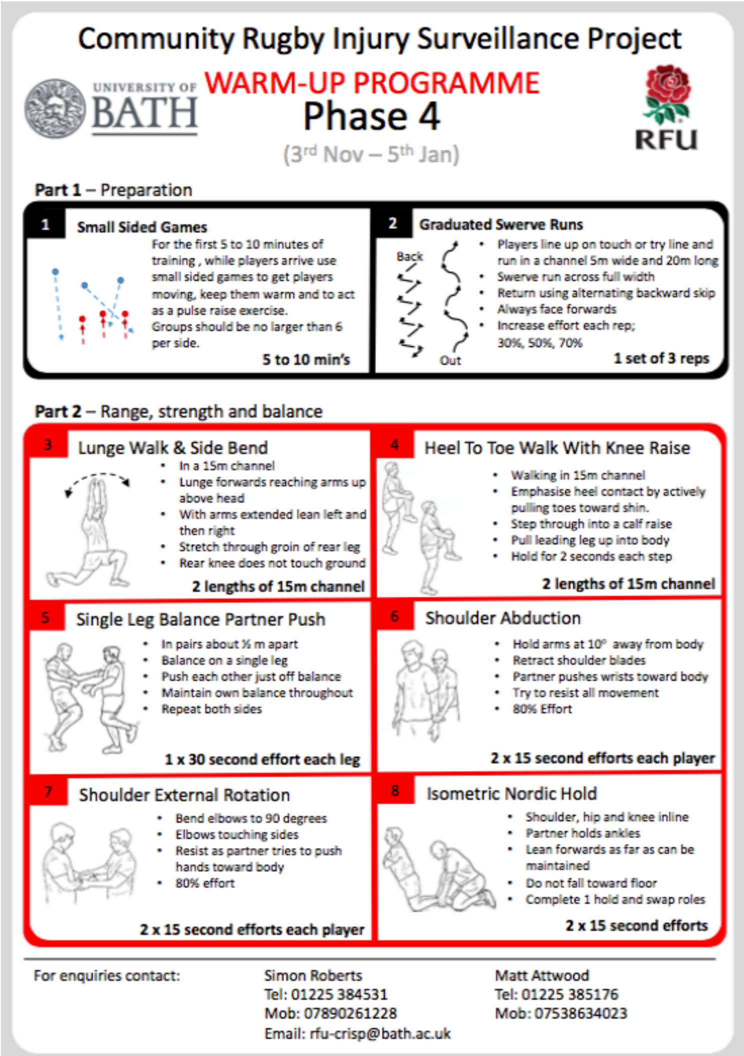

Community Rugby Injury Surveillance Project

University of BATH

WARM-UP PROGRAMME
Phase 4

(3rd Nov – 5th Jan)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training, while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise. Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Lunge Walk & Side Bend

- In a 15m channel
- Lunge forwards reaching arms up above head
- With arms extended lean left and then right
- Stretch through groin of rear leg
- Rear knee does not touch ground

2 lengths of 15m channel

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Partner Push

- In pairs about ½ m apart
- Balance on a single leg
- Push each other just off balance
- Maintain own balance throughout
- Repeat both sides

1 x 30 second effort each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Isometric Nordic Hold

- Shoulder, hip and knee inline
- Partner holds ankles
- Lean forwards as far as can be maintained
- Do not fall toward floor
- Complete 1 hold and swap roles

2 x 15 second efforts

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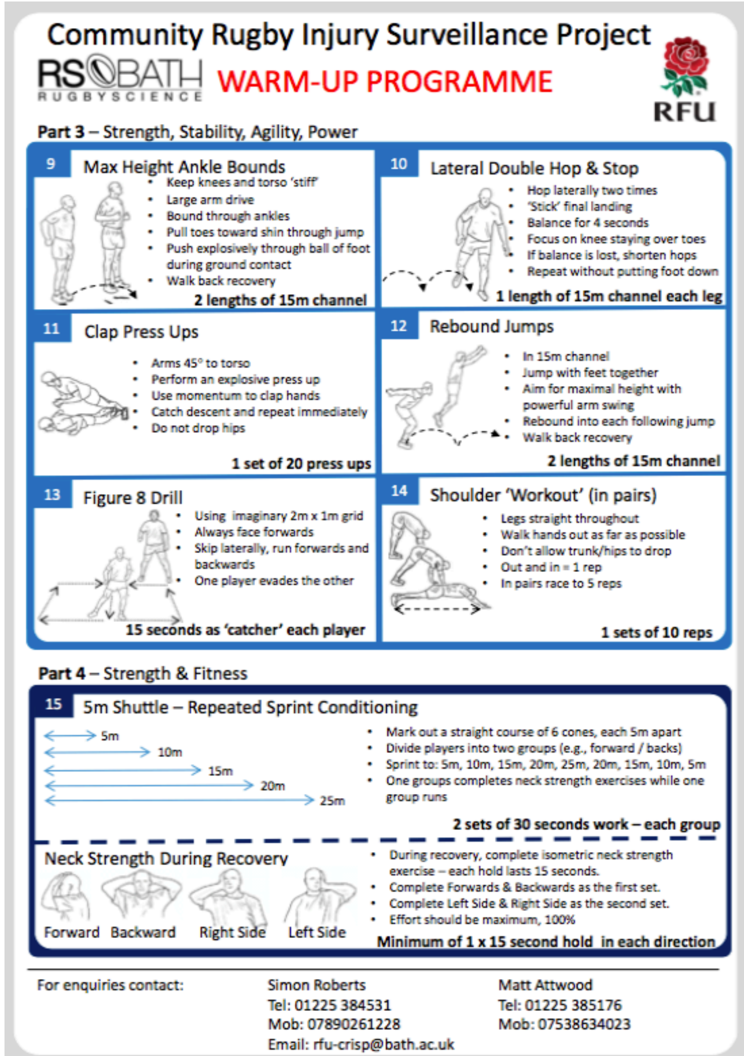

Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Max Height Ankle Bounds

- Keep knees and torso 'stiff'
- Large arm drive
- Bound through ankles
- Pull toes toward shin through jump
- Push explosively through ball of foot during ground contact
- Walk back recovery

2 lengths of 15m channel

10 Lateral Double Hop & Stop

- Hop laterally two times
- 'Stick' final landing
- Balance for 4 seconds
- Focus on knee staying over toes
- If balance is lost, shorten hops
- Repeat without putting foot down

1 length of 15m channel each leg

11 Clap Press Ups

- Arms 45° to torso
- Perform an explosive press up
- Use momentum to clap hands
- Catch descent and repeat immediately
- Do not drop hips

1 set of 20 press ups

12 Rebound Jumps

- In 15m channel
- Jump with feet together
- Aim for maximal height with powerful arm swing
- Rebound into each following jump
- Walk back recovery

2 lengths of 15m channel

13 Figure 8 Drill

- Using imaginary 2m x 1m grid
- Always face forwards
- Skip laterally, run forwards and backwards
- One player evades the other

15 seconds as 'catcher' each player

14 Shoulder 'Workout' (in pairs)

- Legs straight throughout
- Walk hands out as far as possible
- Don't allow trunk/hips to drop
- Out and in = 1 rep
- In pairs race to 5 reps

1 sets of 10 reps

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m / 10m / 15m / 20m / 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

2 sets of 30 seconds work – each group

Neck Strength During Recovery

Forward / Backward / Right Side / Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

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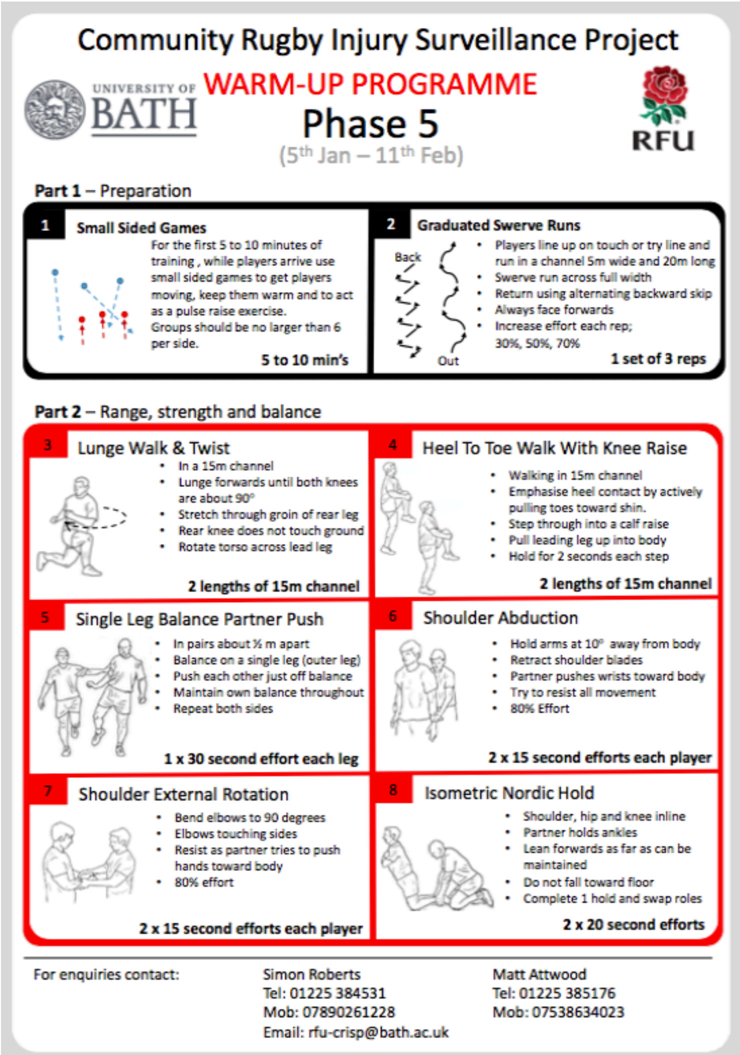

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 5

(5th Jan – 11th Feb)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Lunge Walk & Twist

- In a 15m channel
- Lunge forwards until both knees are about 90°
- Stretch through groin of rear leg
- Rear knee does not touch ground
- Rotate torso across lead leg

2 lengths of 15m channel

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Partner Push

- In pairs about ½ m apart
- Balance on a single leg (outer leg)
- Push each other just off balance
- Maintain own balance throughout
- Repeat both sides

1 x 30 second effort each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Isometric Nordic Hold

- Shoulder, hip and knee inline
- Partner holds ankles
- Lean forwards as far as can be maintained
- Do not fall toward floor
- Complete 1 hold and swap roles

2 x 20 second efforts

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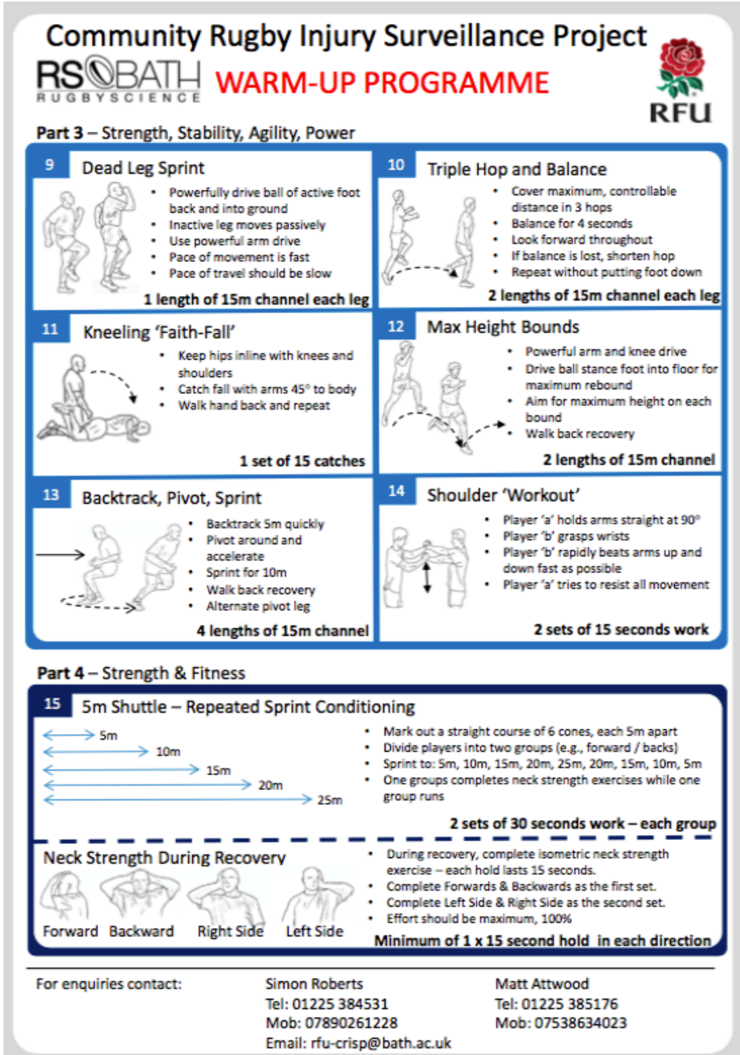

Community Rugby Injury Surveillance Project

RSBATH RUGBYSCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Dead Leg Sprint

- Powerfully drive ball of active foot back and into ground
- Inactive leg moves passively
- Use powerful arm drive
- Pace of movement is fast
- Pace of travel should be slow

1 length of 15m channel each leg

10 Triple Hop and Balance

- Cover maximum, controllable distance in 3 hops
- Balance for 4 seconds
- Look forward throughout
- If balance is lost, shorten hop
- Repeat without putting foot down

2 lengths of 15m channel each leg

11 Kneeling 'Faith-Fall'

- Keep hips inline with knees and shoulders
- Catch fall with arms 45° to body
- Walk hand back and repeat

1 set of 15 catches

12 Max Height Bounds

- Powerful arm and knee drive
- Drive ball stance foot into floor for maximum rebound
- Aim for maximum height on each bound
- Walk back recovery

2 lengths of 15m channel

13 Backtrack, Pivot, Sprint

- Backtrack 5m quickly
- Pivot around and accelerate
- Sprint for 10m
- Walk back recovery
- Alternate pivot leg

4 lengths of 15m channel

14 Shoulder 'Workout'

- Player 'a' holds arms straight at 90°
- Player 'b' grasps wrists
- Player 'b' rapidly beats arms up and down fast as possible
- Player 'a' tries to resist all movement

2 sets of 15 seconds work

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m, 10m, 15m, 20m, 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

2 sets of 30 seconds work – each group

Neck Strength During Recovery

Forward Backward Right Side Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

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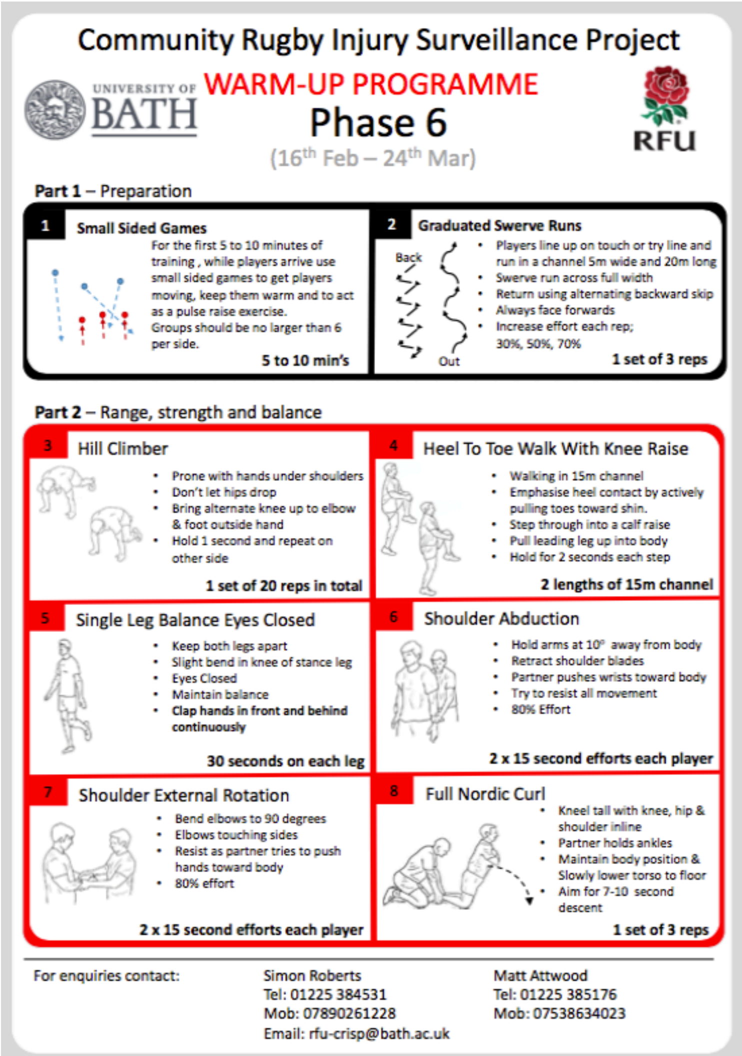

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 6

(16th Feb – 24th Mar)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back / Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Hill Climber

- Prone with hands under shoulders
- Don't let hips drop
- Bring alternate knee up to elbow & foot outside hand
- Hold 1 second and repeat on other side

1 set of 20 reps in total

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Single Leg Balance Eyes Closed

- Keep both legs apart
- Slight bend in knee of stance leg
- Eyes Closed
- Maintain balance
- **Clap hands in front and behind continuously**

30 seconds on each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Full Nordic Curl

- Kneel tall with knee, hip & shoulder inline
- Partner holds ankles
- Maintain body position & Slowly lower torso to floor
- Aim for 7-10 second descent

1 set of 3 reps

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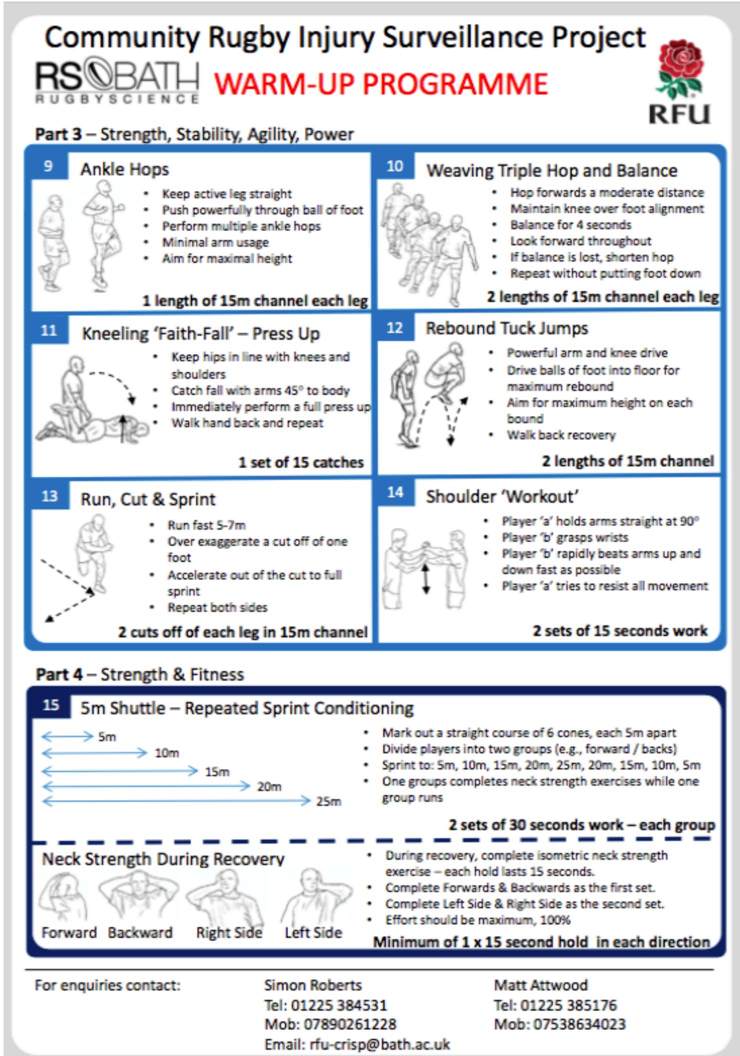

Community Rugby Injury Surveillance Project

RS BATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Ankle Hops

- Keep active leg straight
- Push powerfully through ball of foot
- Perform multiple ankle hops
- Minimal arm usage
- Aim for maximal height

1 length of 15m channel each leg

10 Weaving Triple Hop and Balance

- Hop forwards a moderate distance
- Maintain knee over foot alignment
- Balance for 4 seconds
- Look forward throughout
- If balance is lost, shorten hop
- Repeat without putting foot down

2 lengths of 15m channel each leg

11 Kneeling 'Faith-Fall' – Press Up

- Keep hips in line with knees and shoulders
- Catch fall with arms 45° to body
- Immediately perform a full press up
- Walk hand back and repeat

1 set of 15 catches

12 Rebound Tuck Jumps

- Powerful arm and knee drive
- Drive balls of foot into floor for maximum rebound
- Aim for maximum height on each bound
- Walk back recovery

2 lengths of 15m channel

13 Run, Cut & Sprint

- Run fast 5-7m
- Over exaggerate a cut off of one foot
- Accelerate out of the cut to full sprint
- Repeat both sides

2 cuts off of each leg in 15m channel

14 Shoulder 'Workout'

- Player 'a' holds arms straight at 90°
- Player 'b' grasps wrists
- Player 'b' rapidly beats arms up and down fast as possible
- Player 'a' tries to resist all movement

2 sets of 15 seconds work

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m, 10m, 15m, 20m, 25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

2 sets of 30 seconds work – each group

Neck Strength During Recovery

Forward, Backward, Right Side, Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

For enquiries contact:
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Matt Attwood, Tel: 01225 385176, Mob: 07538634023

Community Rugby Injury Surveillance Project

UNIVERSITY OF BATH

WARM-UP PROGRAMME

Phase 7

(29th Mar – End of Season)

RFU

Part 1 – Preparation

1 Small Sided Games

For the first 5 to 10 minutes of training , while players arrive use small sided games to get players moving, keep them warm and to act as a pulse raise exercise.
Groups should be no larger than 6 per side.

5 to 10 min's

2 Graduated Swerve Runs

Back

Out

- Players line up on touch or try line and run in a channel 5m wide and 20m long
- Swerve run across full width
- Return using alternating backward skip
- Always face forwards
- Increase effort each rep; 30%, 50%, 70%

1 set of 3 reps

Part 2 – Range, strength and balance

3 Hill Climber & Twist

- Prone with hands under shoulders
- Don't let hips drop
- Bring alternate knee up to elbow & foot outside hand
- Raise opposite arm upwards
- Hold 1 second and repeat

1 set of 20 reps in total

4 Heel To Toe Walk With Knee Raise

- Walking in 15m channel
- Emphasise heel contact by actively pulling toes toward shin.
- Step through into a calf raise
- Pull leading leg up into body
- Hold for 2 seconds each step

2 lengths of 15m channel

5 Eyes Closed Partner Push

- Keep both legs apart
- Slight bend in knee of stance leg
- Eyes Closed
- Maintain balance
- Clap hands in front and behind
- Repeat both legs

20 seconds on each leg

6 Shoulder Abduction

- Hold arms at 10° away from body
- Retract shoulder blades
- Partner pushes wrists toward body
- Try to resist all movement
- 80% Effort

2 x 15 second efforts each player

7 Shoulder External Rotation

- Bend elbows to 90 degrees
- Elbows touching sides
- Resist as partner tries to push hands toward body
- 80% effort

2 x 15 second efforts each player

8 Full Nordic Curl

- Kneel tall with knee, hip & shoulder inline
- Partner holds ankles
- Maintain body position &
- Slowly lower torso to floor
- Aim for 7-10 second descent

1 set of 3 reps

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Community Rugby Injury Surveillance Project

RSBATH RUGBY SCIENCE

WARM-UP PROGRAMME

RFU

Part 3 – Strength, Stability, Agility, Power

9 Ankle Hops

- Keep active leg straight
- Push powerfully through ball of foot
- Perform multiple ankle hops
- Minimal arm usage
- Aim for maximal height

1 length of 15m channel each leg

10 Max Hop & Dip

- Maximal controllable hop
- Stick landing
- Perform single leg squat
- Aim for knee over foot
- Repeat without placing passive leg on ground

2 sets of 7 hops each leg

11 Kneeling 'Faith-Fall' – Clap Press Up

- Keep hips in line with knees and shoulders
- Catch fall with arms 45° to body
- Immediately perform a clapping press up
- Walk hand back and repeat

1 set of 15 catches

12 Weaving Rebound Tuck Jumps

- Powerful arm and knee drive
- Drive balls of feet into floor for maximum rebound
- Aim for maximum height on each bound
- Travel ½ m left to right each jump
- Walk back recovery

2 lengths of 15m channel

13 Run, Cut & Sprint

- Run fast 5-7m
- Over exaggerate a cut off of one foot
- Immediately pivot & accelerate up to a full sprint

2 cuts off of each leg in 15m channel

14 Shoulder 'Workout'

- Player 'a' holds arms straight at 90°
- Player 'b' grasps wrists
- Player 'b' rapidly beats arms up and down fast as possible
- Player 'a' tries to resist all movement

2 sets of 15 seconds work

Part 4 – Strength & Fitness

15 5m Shuttle – Repeated Sprint Conditioning

5m
10m
15m
20m
25m

- Mark out a straight course of 6 cones, each 5m apart
- Divide players into two groups (e.g., forward / backs)
- Sprint to: 5m, 10m, 15m, 20m, 25m, 20m, 15m, 10m, 5m
- One groups completes neck strength exercises while one group runs

2 sets of 30 seconds work – each group

Neck Strength During Recovery

Forward Backward Right Side Left Side

- During recovery, complete isometric neck strength exercise – each hold lasts 15 seconds.
- Complete Forwards & Backwards as the first set.
- Complete Left Side & Right Side as the second set.
- Effort should be maximum, 100%

Minimum of 1 x 15 second hold in each direction

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Appendix Q. Full list of injuries reported during the trial and included during intention to treat analysis. The right column demonstrates injury diagnoses removed to conform with the ‘targeted injury’ definition.

	Targeted Injuries	Injuries Removed
Lower-limb		
	Cartilage damage/meniscus tear	Bruise/haematoma
	Dislocation	Fracture
	Joint sprain/jar	Laceration
	Ligament sprain/tear/rupture	Pain undiagnosed
	Muscle tear/strain	
	Nerve injury	
	Tendon injury	
Torso		
		Bruise/haematoma
		Fracture
		Jar/joint injury
		Muscle spasm/winding
		Muscle strain
		Pain undiagnosed
Upper-limb		
	Glenohumoral dislocation	Acromioclavicular joint sprain
	Glenohumoral jar/joint injury	Bruise/haematoma
	Glenohumoral muscle tear/strain	Elbow jar/joint
	Muscle strain	Elbow ligament sprain/tear
	Nerve injury incl. burner/stinger	Elbow pain/undiagnosed
	Tendon injury	Finger joint dislocation
		Fracture
		Wrist ligament tear/sprain
Head & Neck		
	Concussion	Bruise/haematoma
	Neck ligament tear/sprain	Eye injury/trauma
	Neck nerve injury	Fracture
		Laceration
		Pain undiagnosed