Development of a Functional Movement Screening Tool for Football

By

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A thesis submitted in partial fulfilment for the requirements for the degree of Professional Doctorate in Research for Professional Practice at the University of Central Lancashire

March, 2014

STUDENT DECLARATION FORM

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

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Type of Award **Professional Doctorate in Research for Professional Practice**

School **School of Health & Social Development**

ABSTRACT

Introduction: Football is one of the most popular sports world-wide. As with any sport, there is a risk of injury during participation. Therefore screening procedures are important not only to reduce the risk of injury but also for developing subsequent injury prevention programmes. Assessing functional movement is vital in screening in order to examine an athlete's ability to perform fundamental tasks required for a specific sport. Currently in football no standardised functional screening protocols are widely available.

Aim: To Develop a Functional Movement Screening Tool for Football

Method Phase 1: A modified online, two round Delphi consensus panel was utilised to establish which tests should be included in a Functional Movement Screening Tool for Football. The panel of experts consisted of Physiotherapists working in Premiership Football.

Results Phase 1: 14 Premiership Football Physiotherapists participated in Round 1 and 8 Premiership Football Physiotherapists in Round 2. After the completion of two rounds, the Delphi consensus panel identified 12 tests that should be included in a Functional Movement Screening Tool for Football.

Method Phase 2: An online questionnaire survey was used to explore the level of agreement of Physiotherapists working in non-Premiership football on the 12 tests selected in *Phase 1.* This was distributed through email, postal invites and via twitter. Each participant was asked to rate their level of agreement with each test selected for the Functional Movement Screening Tool for Football.

Results Phase 2: 26 Physiotherapists working in non-Premiership football agreed with the inclusion of 10 out of the 12 tests selected by the consensus panel in *Phase 1.* The single-leg squat, deep squat, in-line lunge, Y-balance test, modified Thomas test, internal rotators of the hip assessment, vertical jump test, external rotators of the hip assessment, adductor/groin flexibility test and gastrocnemius test were included in the final Functional Movement Screening Tool for Football.

Discussion: A total of 40 Physiotherapists working in football collectively identified 10 tests to be included in a Functional Movement Screening Tool for Football. Although 10 tests have been identified for inclusion in the screening tool, standardised procedures still need to be defined for each test. Interestingly the tests selected for inclusion in the Functional Movement Screening Tool for Football were a combination of functional, balance, performance and muscle length tests. This highlights either a lack of understanding around the term functional movement or identifies a need for an overall screening tool in football as no standardised protocol is widely available at present.

Conclusion: A screening tool specific for football has been developed. The use of a modified Delphi consensus panel successfully recruited and gained the views from Premiership Football Physiotherapists, a population which is normally difficult to access. Further research into the reliability and validity of the screening tool need to be examined in future studies. Successful methods for overcoming barriers in performing football research have been identified; in particular twitter may serve as a valuable resource for knowledge sharing in football.

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ACKNOWLEDGEMENTS

First and foremost I would like to thank my two supervisors, Professor Jim Richards and Professor James Selfe for their unconditional support and exceptional guidance throughout the duration of this project. Your expert knowledge, patience, compassion and amusing drawings on my draft work have assisted me in completing this study.

Secondly I would like to express gratitude to the University of Central Lancashire, Division of Sport Tourism and The Outdoor for allowing me the opportunity to undertake a Professional Doctorate. I could not have completed this thesis without your support. In particular I would like to thank Karen and Liz for always being therefore me professionally and personally.

Importantly, I would like to thank my friends and family for the countless hours of academic and emotional support. My mother, my chief editor, and my sister and father, you have supported me in every venture in life I have taken and I appreciate this more than you will ever know. Tara, Claire, Zoe, Sheenagh and Gemma, thank you for the endless cups of coffee, encouraging words and late night editing sessions. Armo, Ricky and Matt, glad we were all in this together, thanks for the continued encouragement and comparison of word counts. James, thanks for your patience and for never complaining about the fact that every surface of our house is covered in journal articles and textbooks.

Finally, a warm thank you to all participants that were involved in this study. This project would not have been possible without your time and participation.

1.0 CHAPTER ONE INTRODUCTION

1.1 Introduction to the Topic

Football is said to be the most popular sport world-wide with approximately 240-265 million amateur players and 200,000 professional players (FIFA, 2013; Emery, Meeuwisse and Hartmann, 2005; Junge, Rosch, Peterson, Graf-Baumann and Dvorak, 2002). The sport is played by men and women of varying ages and abilities (Ekstrand, Hagglund and Walden, 2011; Ekstrand, Hagglund and Walden, 2009; Emery et al, 2005). Football is a high-intensity, complex contact sport with long-lasting intervals of exercise (Requena, Gonzalez-Badillo, Villareal, Ereline, Garcia, Gapeyeva and Paasuke, 2009; Arnson, Gudmundsson, Holme, Engebretsen and Bahr, 2004). The sport predominantly relies on the aerobic energy system but during the game a number of skills such as jumping, kicking, turning and sprinting which challenge the neuromuscular system are also required (Requena et al, 2009; Arnson et al, 2004). As with any sport, injuries occur in football both in training and match environments (Ekstrand et al, 2011; Emery et al, 2005; Junge et al 2002).

Several studies have investigated injury incidence and prevalence in football. Overall the incidence of injuries is estimated to be approximately 10-35 injuries per 1,000 match hours (Emery et al, 2005; Witvrouw, Danneels, Asselman, D'Have and Cambier, 2003; Junge et al, 2002) and 1.5-7.6 injuries per 1,000 training hours (Junge et al, 2002). It has been found that the highest injury rate is to the lower extremities accounting for 65-92% of all injuries (Ekstrand et al, 2011; Ekstrand et al, 2009; Bradley and Portas, 2007; Witvrouw et al, 2003; Hawkins, Hulse, Wilkinson, Hodson and Gibson, 2001). Four primary injury types are seen in football; ankle and knee sprains, and hamstring and groin strains, accounting for more than 50% of all injuries (Engebretsen, Myklebust, Holme, Engebretsen and Bahr, 2008). Within the literature muscle injuries as a group are reported to account for approximately 20-37% of injuries in professional players and 18-23% of amateur football players (Ekstrand et al, 2011; Ekstrand et al, 2009; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983).

Although all injuries cannot be prevented, even preventing one injury will have improved the athlete’s performance and physical condition (Ekstrand et al, 2011; Bradley and Portas, 2007; Witvrouw et al, 2003). One of the most recognised methods for identifying risk factors and developing injury prevention strategies involves screening athletes (Schneiders, Davidson, Horman and Sullivan, 2011; Blanch, 2005; Rosch, Hodson, Peterson, Graf-Baumann, Junge, Chomiak and Dvorak; 2000). Screening procedures are well established components of national and international sports programmes (Schneiders et al, 2011; Carek and Mainous, 2003). Screening can be used to identify potential injury and illness risk factors such as specific musculoskeletal problems, cardiac disease and head injuries (Schneiders et al, 2011; Blanch, 2005; Carek and Mainous, 2003). These procedures can also be used to assist in injury prevention by identifying those with sport related functional deficits (Schneiders et al, 2011; Whatman, Hing and Hume, 2011). The results of the screening tests can then be used to individualise training programmes and potentially enhance sporting performance and reduce injury risk (Schneiders et al, 2011; Blanch, 2005; Carek and Mainous, 2003).

Screening is also referred to as pre-participation or pre-season screening and it is used in many sports world-wide (Mottram & Comerford, 2007; Carek and Mainous, 2003). Pre-participation data can be used to identify those whom may be at risk of injury. It can also be used to discover talent, advance skills, and provide baseline data for return to sport after injury and to develop a profile which reflects the characteristics held by those participating in the sport (Cone, 2012; Rosch et al, 2000). However, pre-participation screening is a vague term with there being no set or published criterion on which tests should be included in the tool (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). Over the past few decades, a large amount of tests and categories has been included in the screening tools within the literature. These can cover medical tests such as an electrocardiogram all the way to plinth based strength tests and expensive laboratory based movement analysis (Schneiders et al, 2011; Blanch, 2005; Carek and Mainous, 2003; Rosch et al, 2000). These may also include medical questionnaires, screening of the musculoskeletal system, dietary intake and fitness levels (Mottram & Comerford, 2007; Blanch, 2005; Bahr and Holme, 2003). The range of tests selected for screening appears to be based on numerous factors. Some of these factors included the sport to be played, level of participation, financial implications and injury risk information (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). Bahr and Holme (2003) suggest it is essential to study factors which we can potentially modify. These factors often include but are not limited to anthropometric data, musculoskeletal factors and physical fitness (Mottram & Comerford, 2007; Blanch, 2005; Bahr and Holme, 2003).

Musculoskeletal screening is the process of systematically looking at an athlete's joint range of movement, flexibility, strength, proprioception and balance (Mottram & Comerford, 2007; Blanch, 2005; Bahr and Holme, 2003). The purpose of these tests is to identify characteristics which are less than ideal and to document normal and abnormal ranges. From these tests, recommendations for injury prevention and performance enhancement can be made (Mottram & Comerford, 2007; Blanch, 2005; Bahr and Holme, 2003). This data can also be used to devise a baseline measure for an athlete returning to sport after an injury or for monitoring their continual performance. Musculoskeletal screening is commonly performed by Physiotherapists, Sports Therapists, Strength and Conditioners or Doctors (Mottram & Comerford, 2007; Blanch, 2005).

Examination and assessment form an essential part of a Physiotherapist's professional role. Currently a large proportion of musculoskeletal assessment tools are centred on validated tests measuring range of movement, strength, and balance in an isolated, non-functional way (Mottram & Comerford, 2007; Blanch, 2005). In order to fully assess a client, functional movement screening is vital (Schneiders et al, 2011; Requena et al, 2009; Rosch et al 2000). This allows a therapist to assess the patient's functional capabilities which is often more applicable and more important to the client.

Over the last decade the particular area of functional screening has become increasingly popular. Many Physiotherapists have identified functional movement screening as a vital component of their examination and assessment of an athlete. Despite its popularity, little research has been published on what constitutes a functional movement and should these movements be the same regardless of the sport in which the athlete participates. Schneiders et al (2011) highlight that assessing basic fundamental movements through a more functional approach has the potential to focus on modifying sporting movement patterns rather than just concentrating on specific muscles or joints. Rosch et al (2000) further support this by suggesting performance tests need to be designed to closely replicate the players' normal activities. In particular for football this means including flexibility, movement patterns of main joints, specific football skills, power, speed and endurance (Requena et al, 2009; Rosch et al 2000). Balsom (1994) agree with these statements but also state that the specific testing programmes should identify a player's physical profile revealing their strengths and weaknesses. The testing battery should also be able to be used again to monitor progression of rehabilitation programmes for injured athletes (Requena et al, 2009; Rosch et al 2000; Balsom, 1994).

Functional movement screening is a recent development within Physiotherapy but has yet to be put under the scrutiny of substantial reliability and validity testing. Currently Physiotherapists use functional movement tests and in particular the Functional Movement Screen (FMS) as a screening tool in sport (Cook, 2003). However there is little conclusive evidence supporting the reliability and validity of the FMS. Furthermore there is a lack of evidence to support the inclusion of the functional movement tests selected for the FMS and their relevance to screening tools for specific client groups. In light of this, the study aimed to investigate which movement tests should be included in a functional movement screening tool specifically for football. After establishing which tests should be in a Functional Movement Screening Tool for Football, the screening tool will be re-evaluated in different populations to gain opinions on the developed tool.

1.2 Introduction to the Thesis

In order to achieve the overall aims of the research, this study was broken down into 2 phases; *Phase 1* and *Phase 2*. The research has been presented in chapters to show the development and progression of the thesis. This chapter, Chapter One, introduces the topic of functional screening in football and gives an overview of the chapters covered in this piece of work.

Chapter Two sets the scene of the research and identifies the current gap in knowledge with functional movement screening in football. In Chapter Two, the research strategy is clearly outlined and key sources identified. Chapter Two also provides a comprehensive review of the literature which has been broken down into sections. This will include injury epidemiology in football, injury risk factors in football, FIFA Medical and Research Council (F-MARC), football screening, functional screening in sport and the Functional Movement Screen (FMS). Chapter Two closes with stating the aims and objectives of this study.

As this study has been broken down into two phases, Chapter Three describes the methodology that was used in *Phase 1* of the research. This includes the rationale for the choice in methodology, participant considerations and recruitment, development and presentation of the questionnaires used in *Phase 1*, ethical issues, and data storage.

Chapter Four presents the descriptive data for the information gained in *Phase 1* of the study. It is presented in tables and text to allow the reader to clearly see the data collected in *Phase 1*. Chapter Four identified the functional movement tests selected by 75% or more participants in *Phase 1* for inclusion into *Phase 2* of this study. Full results have also been made available in the appendices.

In Chapter Five results from *Phase 1* are discussed and the development of *Phase 2* of the research evolves in this section. Chapter Five outlines the initial and revised aims of *Phase 2* of this study and provide rationale for changes in the project after completing *Phase 1*. Limitations of the methodology in *Phase 1* are also addressed in this chapter.

Chapter Six provides details of the methodology utilised in *Phase 2* of the research. As with Chapter Three, participant considerations and recruitment, development and presentation of the questionnaires used in *Phase 2*, ethical issues and data storage are addressed in Chapter Six.

Chapter Seven illustrates the results from *Phase 2* of the study. Graphs, text and tables have been used to show the data collected in *Phase 2*. Combined data as well as grouped data have been presented in Chapter Seven. This shows the overall views of the participants in *Phase 2* as well as a breakdown of results in relation to their level of employment in football.

Chapter Eight presents the tests that have been chosen for inclusion in the final Functional Movement Screening Tool for Football. Information on each test, including the test protocol, reliability and validity information is discussed and critically analysed. Limitations of *Phase 2* are highlighted and reviewed.

Chapter Nine addresses the clinical implications of the research. This covers both the implications for Physiotherapists working in football and the applicability of the test in the football community. Potential clinical limitations are also acknowledged.

Chapter Ten acknowledges the overall limitations of the study. Suggestions for addressing these limitations are discussed. Recommendations for future research are also identified in Chapter Ten.

Finally Chapter Eleven provides overall conclusions of the study. This chapter synthesises the information from all chapters of the thesis and provides the overall research summary. Recommendations and limitations of the use of the Functional Movement Screening Tool for Football are reiterated.

1.3 Aims and Objectives of *Phase 1*

The overall aim of *Phase 1* was to establish which tests should be included in a Functional Movement Screening Tool for Football and to define operational protocols for the included tests. This was broken down into two phases: *Phase 1A* and *Phase 1B*.

1.3.1 Aims of *Phase 1A*

The aim of *Phase 1A* was to establish which tests should be included in a Functional Movement Screening Tool for Football using an online Delphi consensus panel of experts.

1.3.2 Objectives of *Phase 1A*

Phase 1A had the following objectives:

1. To select a group of clinical experts, Physiotherapists from the English Premier Football League, to form a consensus panel.
2. To determine which tests should be included in a Functional Movement Screening Tool for Football by using a two round modified Delphi technique utilising an online survey process.
3. To establish consensus within the group of clinical experts as to which tests will be included in a Functional Movement Screening Tool for Football.

1.4 Aims and Objectives of *Phase 1B*

1.4.1 Aims of *Phase 1B*

After establishing which tests were included in the Functional Movement Screening Tool for Football in *Phase 1A*, *Phase 1B* aimed to establish operational definitions of each test for the Functional Movement Screening Tool for Football.

1.4.2 Objectives of *Phase 1B*

Phase 1B had the following objectives:

1. To recruit a group of Physiotherapists from the consensus panel of experts to continue to participation in the study and the development of the Functional Movement Screening Tool for Football.
2. To determine operational definitions for evaluating correct performance for each test included in the Functional Movement Screening Tool for Football using an online discussion board.

1.5 Aims and Objectives of *Phase 2*

1.5.1 Aims of *Phase 2*

Overall the study aimed to develop a Functional Movement Screening tool that is specifically designed for use in football. *Phase 2* aimed to evaluate the agreement levels for each of the tests that have been selected to be included in the screening tool by the consensus panel in *Phase 1*.

1.5.2 Objectives of *Phase 2*

1. To recruit up to 30 Physiotherapists working in non-Premiership football to evaluate the Functional Movement Screening Tool for Football developed in *Phase 1*.
2. To disseminate the Functional Movement Screening Tool for Football developed in *Phase 1* to the recruited group.
3. To explore the agreement level of the recruited group on each of the tests included in the Functional Movement Screening Tool for Football developed in *Phase 1*.

2.0 CHAPTER TWO REVIEW OF THE LITERATURE

2.1 Literature Search Strategy

In order to access the relevant literature for this review, the following search strategy was utilised. Databases such as SPORTDiscus, Science Direct, Discovery, MEDLINE and PubMed were accessed. Specific journals were also targeted for this review: The American Journal of Sports Medicine, British Journal of Sports Medicine, and the Scandinavian Journal of Medicine and Science in Sport were all accessed. The Journal of Strength and Conditioning was also accessed as a number of Functional Movement Screening studies were published in this specific journal. Combinations of the following key terms were used: football, soccer, screening, functional screening, functional movement screening, FMS, profiling, injury risk factors, epidemiology, injury incidence, injury prevalence, injury screening, injury prediction and injury prevention. Date restrictions were limited to 2000-Present to ensure current literature was accessed. After reviewing the literature a few older pieces of work have been included into this literature review as they were found to be frequently used in other key pieces of research. Advanced search settings were set to limit search results to only articles in English.

2.2 Injury Epidemiology in Football

Understanding injury incidence for a particular sport allows for identification of tests that may predict these injuries and can assist in injury prevention programmes (Hawkins et al, 2001). Therefore it is important to review the injury epidemiology in football when considering which tests are appropriate for inclusion in to a Functional Movement Screening Tool for Football. An enormous amount of studies were found to have examined epidemiology in football and it would therefore be impossible to discuss them all in this review. For that reason this section will only review the early epidemiology study by Ekstrand & Gillquist (1983) that is frequently referred to in other studies, then subsequently recent studies with large sample sizes conducted over more than one football season. Currently there are not standardised categories for reporting injury epidemiology in football, therefore making it difficult to compare across studies in time. At the end of this section, 2 summary tables have been provided to enable comparison across the studies presented (Table 1, pg 15; Table 2, pg 16).

Ekstrand & Gillquist (1983) identified previous studies on injury epidemiology in football lacked clear injury definitions making it difficult to gain a clear indication of injury incidence in football. They also recognised that conducting a prospective study in football was needed to identify injury mechanism and types to assist in developing injury prevention strategies. Therefore Ekstrand & Gillquist (1983) studied 180 senior male football players from 12 different teams over one year. However, specific details about the level and country of play were not provided. Although Ekstrand & Gillquist (1983) stated all injured players were examined by the same orthopaedic surgeon, details of this process were not defined. Pre-determined injury definitions were used and the severity of injury was classified into 3 categories; minor, moderate and major.

Ekstrand & Gillquist (1983) reported that 124 players sustained a total of 256 injuries over the year studied. Lower extremity injuries represented 88% of all injuries, 69% caused by trauma and 31% by overuse. Sprains accounted for 29% of all injuries; ankle sprains (59%) and knee sprains (34%) of total sprains. Muscle strains were reported at 18% of all injuries, 80% which occurred to the lower extremity with the hamstrings being the most frequently injured (38%) followed by the quadriceps (16%), adductors (16%) and gastrocnemius (11%). With regards to injury location, knee injuries (20%) were the most prevalent then subsequently the ankle (17%), thigh (14%) and groin (13%). Classification of severity revealed 62% of all injuries were considered minor, 27% moderate and 11% severe. A breakdown of injuries incurred during matches and training was not stated, however importantly Ekstrand & Gillquist (1983) identified minor injuries were often followed by a further injury within a two month period. The players in this study returned to sport on their own according thus highlighting the need for procedures that ensures a player is ready to return to training and competition.

Hawkins et al (2001) conducted a prospective epidemiological study of injuries sustained in English professional football over 2 consecutive seasons in 1997-1999. In order to correctly screen for potential injury risk factors, Hawkins et al (2001) state a clear understanding of injuries that occur in a particular sport must be audited first. A total of 91 out of 92 professional teams in England participated with data being collected on 2,376 players.

Hawkins et al (2001) reported 6,030 total injuries over the 2 seasons. As an average this is equivalent to 1.3 injuries per player, per season which is slightly lower than the 2 injuries per player, per season reported by Ekstrand et al (2009). Approximately 63% of injuries were sustained during matches, 34% occurred in training and 3% were unspecified. Interestingly Hawkins et al (2001) reported 87% of all injuries affected the lower extremity which is the same proportion stated by Ekstrand et al (2009). Muscle injuries were recorded as the highest type of injury with 2,225 muscle injuries occurring, representing 37% of all injuries. In this study, 749 hamstring injuries and 376 quadriceps injuries were declared. Finally re-injuries only accounted for 7% of total injuries which again is lower than reported in other studies (Inklaar, 1994; Ekstrand and Gillquist, 1983). These findings again highlight muscular injuries as the most common injury. Therefore it is important to investigate injury risk factors for muscle injuries and ways of detecting potential muscle injuries.

Woods, Hawkins, Hulse and Hodson (2002) analysed the injury epidemiology of 91 professional English Football Clubs from July 1997-May 1999. A total of 2,376 players were included in the study with 947 players reporting 6,030 injuries over the study period. Pre-season and competitive season data was recorded with 17% of total injuries occurring in pre-season which was found to be significantly less than the 83% sustained in the competitive season. Woods et al (2002) report this to translate to an average of 0.2 injuries per player, per preseason. Interestingly, the data was not broken down in to percentages of injuries that occurred in match play or training.

Woods et al (2002) found muscle strains/ruptures were the most common injuries sustained, 37% of all injuries. Of the muscle injuries sustained, hamstring strains of the biceps femoris muscle were the most common during the competitive season (21%) and quadriceps most common in pre-season (29%). Ligamentous sprains were the second most common injury sub-type accounting for 19% of all injuries. Woods et al (2002) found that running, which is non-contact, was the most common mechanism of injuries sustained (19%) closely followed by being tackled (15%). A total of 8% of injuries occurred during twisting and turning whereas stretching only accounted for 5% of all injuries. Shooting, passing and landing accounted for 4% each of injuries sustained and jumping 2% of all injuries. The category “other (non-contact)” accounted for 10% of all injuries but no examples of mechanisms in this category were stated.

Walden, Hagglund and Ekstrand (2005) studied the injury epidemiology of 11 clubs participating in the UEFA Champions League during the 2001-2002 season. The data was collected in both pre-season and in the competitive season. In total 266 players participated and 658 injuries were sustained by 225 players; 129 in pre-season and 529 injuries in the competitive season.

Walden et al (2005) found that 85% of the injuries were sustained at the lower extremities. Of these injuries, thigh strains were the most common injury accounting for 16% of all injuries. In relation to strains that occurred, thigh strains accounted for 61% of total strains and posterior thigh strains were significantly more common than anterior thigh strains ($p < 0.0001$). Groin strains had the second highest percentage of strains with 21% reported in this study. With regards to ligament injuries 51% were found to occur at the ankle and 39% at the knee joint. In particular, medial collateral ligament sprains accounted for 53% of total sprains sustained at the knee. Interestingly Walden et al (2005) found the match injury incidence rate to be higher in the English and Dutch leagues and also reported a higher risk of sustaining a major injury in these two leagues.

Ekstrand et al (2009) carried out a large study investigating injury incidence in football over 7 consecutive seasons. During the 2001-2008 seasons, 7 top European football clubs that had been selected by UEFA, participated in collecting data in all 7 seasons. As well as this 16 other football clubs' data has also been included as they participated for at least one full season during the study duration. Therefore in total, 23 clubs collected data on 2,226 players over 88 team seasons. Results presented are based on a typical team of 25 players. The average player was seen to participate in approximately 34 matches and 462 training sessions per season with an overall mean of 254 football hours, 41 match hours and 213 training hours.

Ekstrand et al (2009) reported 4,483 injuries of which 1,937 (43%) occurred in training and 2,546 (57%) occurred in matches. This averaged out to 2 injuries per player, per season. Ekstrand et al (2009) found that of the injuries, 87% occurred in the lower extremities. Muscle and tendon injuries combined accounted for 1,908 injuries, 42% of all injuries sustained. The most frequent injury subtypes were thigh strains, representing 743 injuries (17% of all injuries) with 525 hamstrings strains (12% of thigh strains) being more common than the 218 quadriceps strains (5% of thigh strains). Expressed in terms of injuries per season, on average a team of 25 players can expect approximately 10 thigh muscle strains each season, of which 7 of them affecting the hamstring muscles and 3 the quadriceps muscles (Ekstrand et al, 2009). Re-injuries accounted for 12% of total injuries and this group missed the highest amount of football hours due to injury. However when compared to other studies, this re-injury rate was found to be lower than previously reported data. Ekstrand et al (2009) also reported more injuries to occur in extra-time in the first and second halves but exact figures were not presented. Other common injuries reported were 399 adductor pain/strains (9%), 318 ankle sprains (7%) and 220 medial collateral ligament injuries (5%).

Ekstrand et al (2011) went on to narrow their research by specifically studying epidemiology of muscle injuries in football. Ekstrand et al (2011) decided to research this area as previous studies reported 18-37% of time loss in football was from muscle injuries (Ekstrand et al, 2009; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). Ekstrand et al (2011) wanted to advance this knowledge by specifically researching professional football and by breaking down which specific muscle groups were affected. A total of 2,299 players within European leagues were studied over a number of seasons. Ekstrand et al (2011) reported that one-third of all injuries were muscular in nature. Of particular note, 92% of these injuries affected the four major leg muscle groups: hamstrings (37%), adductors (23%), quadriceps (19%) and calves (13%). The authors also reported that 16% of muscle injuries were classified as re-injuries. From this data one can see muscle injuries and specifically injuries to the four major leg muscle groups account for significant amount of time loss from football. Therefore when performing screening in football it is essential that the leg muscles are tested appropriately to try and reduce the risk of muscular injuries. This is vital as Ekstrand et al (2011) also reported that 95% of muscle injuries were from non-contact situations.

Hagglund, Walden and Ekstrand (2012) reported injuries from 9 consecutive seasons (2001-2010) from 26 football clubs in 10 European countries. The study was performed in collaboration with Union of European Football Association (UEFA) and included a total of 1,401 players. Hagglund et al (2012) followed the UEFA injury definition and data collection protocol for injury surveillance which was previously validated (Hagglund, Walden, Bahr and Ekstrand, 2005). During the 9 seasons, a total of 6,140 injuries were reported. Muscle injuries accounted for 35% (2,123) of all injuries. The muscle injury sites recorded were adductors (523 injuries), hamstrings (900 injuries), quadriceps (394 injuries) and calves (306 injuries). Hagglund et al (2012) reported that adductor, hamstring and calf injuries were more common in pre-season, with quadriceps injuries being the only muscular injury occurring more commonly during the season.

More recently, Ekstrand, Hagglund, Kristenson, Magnusson and Walden (2013) reported results of their prospective study involving 27 male football teams from 10 countries over 11 consecutive seasons (2001-2012). During this time 1,743 players participated with an average of 25 players per team. Ekstrand et al (2013) followed the standardised UEFA data collection model and injury definitions (Hagglund et al, 2005). Overall 8,029 injuries were recorded and 4,546 injuries (57%) were reported during matches and 3,483 injuries (43%) during training. Collectively over all seasons, 7.6 injuries were reported for every 1,000 football hours. Match play accounted for 24.7 injuries per 1,000 playing hours which was 7 times higher than found in training, 4.6/1,000 playing hours. On average it was reported that a team could expect 8 severe injuries per season as serious injuries accounted for 17% of all injuries.

Interestingly, Ekstrand et al (2013) found ligament injuries decreased during the study period but muscle injuries remained stable. Specifically, Ekstrand et al (2013) found a 31% decrease in ligament injuries, 11% which were knee ligament injuries. One given explanation for this was implementation of preventative measures and improved rehabilitation protocols (Ekstrand et al, 2013). Disappointingly muscle injury rates did not decrease showing screening and prevention strategies currently in place have limited effectiveness. Therefore further research on screening strategies and the implications of an increase in matches per year need to be investigated (Ekstrand et al, 2013).

Evidence has shown injury in football continues to remain a problem with rates being reported at a minimum of 1 injury per player per season and approximately 8 severe injuries per team per season (Ekstrand et al 2013; Ekstrand et al, 2011; Hawkins et al, 2001). Despite current research showing there may be a decrease in ligament injuries in football, muscle injuries have not reduced and account for 18-37% of all injuries

(Ekstrand et al, 2013; Ekstrand et al, 2011; Ekstrand et al 2009; Hawkins et al, 2011; Inklaar, 1994; Ekstrand and Gillquist, 1983). These figures highlight a need for improved and potentially more dynamic screening and prevention strategies as current practices have shown limited effectiveness (Ekstrand et al, 2013).

Table 1-Epidemiology of Football Injuries

Study Details	Participant Information	Injuries to the Lower Extremity (% of total injuries)	Ligament Sprains (% of total injuries)	Muscle Strains (% of total injuries) *muscle breakdown Table 3.1
Ekstrand & Gillquist (1982) *reported in section 2.3	180 males senior players; country/level unknown;12 teams	78%	41%	13%
Ekstrand & Gillquist (1983)	180 males senior players; country/level unknown;12 teams	88%	29% (ankle 59%; knee 34%)	18%
Hawkins et al (2001)	2,376 male senior players; 91 English professional teams	87%	19%	37%
Woods et al (2002)	2,376 players; Pre-season; 91 English professional teams	89%	19% (ankle 59%; knee 30%)	37%
Walden et al (2005)	266 males players; 5 European countries; 11 professional teams	85%	21% (ankle 51%; knee 39%)	26%
Ekstrand et al (2009)	2,226 male players; 23 European teams	87%	18% (ankle 7%; MCL 5%)	35%
Ekstrand et al (2011)	2,299 male players; 51 European teams	92%	Muscle injuries only	31%
Hagglund et al (2012)	1,401 male players; 10 European countries; 26 teams	Lower Limb muscle injuries only	Lower Limb muscle injuries only	35%
Ekstrand et al (2013)	1,743 male players; 10 European countries; 27 teams	Not reported	Not reported (ankle 6.9%; MCL 4.3%)	Not reported

Table 2-Epidemiology of Muscle Injuries in Football (% of muscle injuries)

Study Details	Participant Information	Quadriceps (% of muscle injuries)	Hamstrings (% of muscle injuries)	Adductors (% of muscle injuries)	Calves (% of muscle injuries)
Ekstrand & Gillquist (1982) *reported in section 2.3	180 males senior players; country/level unknown;12 teams	10%*	9%*	5%*	Not reported
Ekstrand & Gillquist (1983)	180 males senior players; country/level unknown;12 teams	16%	38%	16%	11% (gastrocnemius)
Hawkins et al (2001)	2,376 male senior players; 91 English professional teams	17%	34%	Not reported	Not reported
Woods et al (2002)	2,376 players; Pre-season; 91 English professional teams	29%	11% (biceps femoris)	12%	Not reported
Walden et al (2005)	266 males players; 5 European countries; 11 professional teams	21%	40%	21%	Not reported
Ekstrand et al (2009)	2,226 male players; 23 European teams	14%	33%	25%	Not reported
Ekstrand et al (2011a)	2,299 male players; 51 European teams	19%	37%	23%	13%
Hagglund et al (2012)	1,401 male players; 10 European countries; 26 teams	19%	42%	25%	14%
Ekstrand et al (2013)	1,743 male players; 10 European countries; 27 teams	5.0%*	12.8%*	9.2%*	4.5%*

*% of total injuries as number of muscle injuries not stated

2.3 Injury Risk Factors in Football

In order to prevent injury in sport, it is imperative to have an understanding of injury epidemiology and potential risk factors leading to injury (Croisier, Ganteaume, Binet, Genty and Ferret, 2008). Numerous studies have investigated risk factors for injuries in football. Throughout the literature factors such as warm-up and cool down strategies, proprioception and balance, flexibility, aerobic conditioning, muscle imbalance, playing field conditions, adherence to rules and recovery time have all been identified as potential risk factors for injury (Witvrouw et al, 2003; Junge et al, 2002).These risk factors have been broken down into intrinsic (person/player-related) and extrinsic (environment-related) risk factors (Junge et al, 2002). Despite a large number of factors proposed in the literature, few have been scientifically proven to be linked to injury. Most potential risk factors have only been implicated within the research (Croisier et al, 2008). Evaluating risk factors in football is important as it allows Physiotherapists and coaches to identify appropriate screening tests and rehabilitation protocols to reduce the potential injury risks (Schneiders et al, 2011; Blanch, 2005; Carek and Mainous, 2003).

Ekstrand & Gillquist (1982) performed one of the first reported studies on the frequency of muscle tightness and injuries sustained in football. Ekstrand & Gillquist (1982) examined 180 senior male football players looking at muscular tightness in the lower extremities, past injury and persistent symptoms from past injury. Ekstrand & Gillquist (1982) defined past injury as any injury that had occurred during sport that required medical attention, hospital admission or absence from training for more than one week. Interviews were conducted with each player and their medical records were reviewed for details of previous injuries. Knee and ankle joint stability tests were performed to analyse persistent symptoms. A total of 5 movements were tested to assess flexibility of the adductors, hamstrings, iliopsoas, rectus femoris and gastrocnemius. The movements were recorded for the 180 football players and 86 male non-football players for comparison of results.

Ekstrand & Gillquist (1982) reported 465 injuries sustained among the 180 players which breaks down to approximately 2.6 injuries per player, per year. Sprains (41%) were the most frequently reported injury type followed by bursitis-tendinitis (15%), strains (13%), fractures (11%) and contusions (11%). With regards to sprains, 82% of all players reported sustaining a previous ankle sprain and 32% a previous knee sprain. Instability was found in 63% of players with previous ankle sprains and 42% of players with previous knee sprains. Ekstrand & Gillquist (1982) reported 39% of players with a previous knee injury had required surgical treatment. In relation to muscle strains, quadriceps was most commonly injured (10%), then hamstrings (9%) and adductors (5%). Specifically hamstring and quadriceps strains were more common on the dominant side which Ekstrand & Gillquist (1982) believe is down to the dynamic activity of the dominant leg while kicking a football. With regards to flexibility football players were significantly less supple than the control group with hip abduction, hip extension, knee flexion and ankle dorsiflexion ($p<0.001$). However the football players had increased flexibility in hip flexion ($p<0.01$). Therefore showing 76% of football players had tightness in one or more muscles in the lower extremity. Interestingly, no differences in muscle tightness were found between injured and non-injured players within the previous year. Although not significant, Ekstrand & Gillquist (1982) point out that 31% of strains occurred in players with muscle tightness, compared with 18% in players who displayed normal flexibility. However, in a retrospective study it is not possible to say if the muscle tightness was present before injury or is a consequence of previous injury or training methods (Ekstrand & Gillquist, 1982). Importantly, Ekstrand & Gillquist (1982) found thigh strains were more common on the kicking leg. As muscle tightness was not linked to thigh injuries, it may be concluded plinth based muscle length tests do not relate to the dynamic movements involved in football.

Witvrouw et al (2003) also conducted a study evaluating muscle flexibility as a possible risk factor for muscle injuries in professional men's football. Witvrouw et al (2003) decided to investigate this topic as literature has reported that previous studies identified that lower limb muscle injuries in sport were common (Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). As a lack of flexibility is frequently linked with muscle injuries, Witvrouw et al (2003) wanted to identify risk factors for these types of injuries.

Prior to the start of a competitive season in Belgium, Witvrouw et al (2003) took lower limb flexibility measures from 249 players. The measurements included flexibility tests from the hamstrings, quadriceps, adductors and gastrocnemius. Angles were recorded from goniometric measures and a standardised protocol which could easily be followed by another tester was used. The hamstrings, quadriceps and adductor measures were taken with the athlete supine on a plinth and the calf measure with the athlete standing in a lunge position. After screening took place 146 athletes were monitored as they fitted the inclusion criteria. From the 146 players included, 67 sustained a lower limb muscle injury which consisted of 31 hamstrings, 13 quadriceps, 13 adductor and 10 calf injuries. When grouped together as non-injured and injured players, the athletes that sustained a muscle injury were found to have a mean flexibility score that was lower than the non-injured group. However, statistically only hamstring injuries were found to be significantly linked to lower flexibility scores ($p \leq 0.05$). A relationship was observed with poor flexibility and the other muscle groups but it was not significant ($p \geq 0.05$). Participants' heights were also recorded but no correlations were found with injury rates (Witvrouw et al, 2003). One acknowledged weakness of this study is that flexibility was the only attribute measured in the study. As discussed with other studies, injuries are often multi-factorial therefore other factors would need to be considered to get a more holistic view. However these results still raise two issues. First of all, there is a possibility that muscle injuries may not be linked to a lack of flexibility in dynamic sport and secondly muscle flexibility tests that are performed lying on a plinth in a non-functional way may not be an appropriate measure or indicator of flexibility required for sport.

Emery et al (2005) used an injury surveillance system to help identify injury risk factors in football. Emery et al (2005) examined 21 adolescent football teams ranging from age 12-18 years. In total 317 players participated, 153 boys and 164 girls. Baseline measures of height, weight, leg dominance, vertical jump, unipedal dynamic balance and 20m shuttle run were recorded as well as the participants completing a medical questionnaire. A team designated volunteer recorded a weekly exposure sheet for each participant that covered training and match hours completed and any injury sustained. Not all participants completed the necessary paperwork resulting in some loss of data.

Emery et al (2005) reported 78 injuries were sustained by 61 players. It was found that girls and boys had similar injury rates with 5.62 and 5.55 injuries respectively per 1,000 playing hours. Overall this was lower than found in adult players (Emery et al, 2005; Witvrouw et al, 2003; Junge et al, 2002). The youngest age group, the under 14's, reported the highest injury rates. Players who were left leg dominant were also found to have an increased injury risk but there was no apparent link to any of the baseline measures recorded by Emery et al (2005). However those who declared a previous injury within the last year were found to be at higher risk for injury which is in agreement with other research (Ekstrand et al, 2011; Ekstrand et al, 2009; Engebretsen et al, 2008; Lehance, Binet and Croisier, 2008; Junge et al, 2002; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). Although Emery et al (2005) did not identify any risk factors with flexibility, balance or strength, the reliability of their study has been significantly reduced as the data was collected by a team designated volunteer and not all data was reported. This may have affected the overall study results.

Engebretsen et al (2010a, 2010b, 2010c, 2010d, 2008) have conducted a number of studies investigating risk of groin and hamstring strains, ankle and knee sprains, and athletes with previous injuries in football. Engebretsen et al (2010a, 2010b, 2010c, 2010d, 2008) discuss results from the same population and the data was collected initially by Engebretsen et al (2008) in an injury prevention study. As no significant differences were found in injury rates between a control and intervention group (Engebretsen et al, 2008), the data was used to assess injury rates and risk factors for each of the above mentioned sections (Engebretsen et al, 2010a, 2010b, 2010c, 2010d). Data was collected on a total of 506 players from 31 teams in the Norwegian 1st, 2nd and 3rd divisions. Every player performed 2 performance tests, the countermovement jump and a 40m sprint and completed a previous injury questionnaire including specific functional outcome scores for the knee and ankle. A physical exam of clinical tests was also carried out on each player based on the F-MARC Football Medicine Manual (2005). At each joint range of motion was assessed and palpation for pain response performed. Specific tests include resisted adductor strength, Nordic hamstring strength, passive knee extension test, foot and knee position, clinical stability tests of the ankle (anterior draw) and knee (lachmans test, anterior draw, valgus/varus stress tests) and single leg stand balance.

Surprisingly Engebretsen et al (2010a, 2010b, 2010c, 2010d) identified few injury risk factors for groin and hamstring strains and ankle and knee injuries. The only common factor was previous injury which was found to be a significant risk factor for new injuries to the groin, hamstrings and ankle; previous injury was not found to be significant predictor for knee injuries (Engebretsen et al, 2010a, 2010b, 2010c, 2010d). The only other factor that was found to be a predictor of injury was weak adductor strength which was related to groin injuries (Engebretsen et al, 2010c). Muscle length was not found to be a predictor of hamstring or groin injuries (Engebretsen et al, 2010c, 2010d). Interestingly Nordic hamstring strength also did not predict hamstring injuries but Engebretsen et al (2010d) believe this may be due to the fact they used an arbitrary scoring system as there is not a recognised one in place. The scoring system they implemented was reported to have low inter-rater reliability (k=0.24). With regards to ankle injuries, single leg stand balance was not found to predict injury and clinical stability tests of the ankle and knee were also not indictors of injury (Engebretsen et al (2010a, 2010b). Thus highlighting non-dynamic tests do not appear to be predictors of injuries in football.

Previous injury has been seen in a number of studies as a key indicator for increased injury risk (Ekstrand et al, 2011; Ekstrand et al, 2009; Engebretsen et al, 2008; Junge et al, 2002). It has been reported that previous injury may compromise joint function and stability, reduce strength and alter muscle flexibility (Engebretsen et al, 2008). Kiesel, Plisky and Butler (2009) also discussed previous injury as a risk factor for further injury. They identified that change in motor control post-injury increased player's risk of subsequent injury. Kiesel et al (2009) suggest isolated impairment measures may not identify the complex deficits that can occur post injury therefore they recommend performing screening tasks requiring full body coordinated movements. In an earlier study, Kiesel, Plisky and Kersey (2008) reported athletes with previous injuries showed asymmetry on functional testing. Kiesel et al (2008) also found those who had asymmetry on the FMS had a 2.3 times greater risk for injury regardless of their overall FMS score.

Muscle strength imbalances have also been reported as intrinsic injury risk factors in sport (Engebretsen et al, 2010c; Croisier et al, 2008; Lehance et al, 2008). In particular, strength imbalances of the quadriceps and hamstrings have been linked as a potential cause for muscle injuries in football (Croisier et al, 2008; Lehance et al, 2008). To investigate this theory, Croisier et al (2008) studied a large sample of 462 football players over the 2000-2005 playing seasons. Players completed isokinetic measurements of hamstring and quadriceps strength prior to the start of the season. They performed both concentric and eccentric contractions of each muscle group in a seated position. Following the testing, players were classified into 4 subsets: no preseason imbalance (246 players), preseason imbalance with no compensating training (91 players), preseason imbalance with compensating training but no further control test (55 players) and preseason imbalances with compensating training until normalisation verified by subsequent testing (70 players).

Croisier et al (2008) found the rate of hamstring muscle injury was significantly increased in those with preseason untreated quadriceps to hamstring muscle strength ratio imbalance ($p \leq 0.05$). The group which performed compensation training but with no further control tests also had a higher injury rate although this was less than the untreated group. Most notably, the group that had compensating training until normalisations was verified through testing showed a reduced injury risk rate demonstrating that a combination of screening to detect imbalances and a corrective exercise programme can reduce injury incidence rates.

As muscle strength is a vital component of the game of football, studies have not only examined muscle imbalances but have also examined muscle strength and functional test performances in the hopes of identifying potential risk factors. Previous studies have aimed to investigate the relationship of strength tests and performance tests such as vertical jump and sprint tests (Engebretsen et al, 2008; Wisloff, Castanga, Helgerud, Jones and Hoff, 2004). In order to establish if strength or functional performance tests were able to predict injury risks, Lehance et al (2008) studied 57 elite and junior male Belgian football players. The participants completed a testing protocol consisting of bilateral isokinetic maximal quadriceps and hamstring strength, vertical jump height and 10m sprint time. Each player also completed an injury history questionnaire.

Results found 32 players had significant strength deficits on isokinetic testing and of the 32 players, 23 had reported previous lower limb injury (64% of all injuries). This is consistent with other studies that have shown sustaining a previous injury is a key injury risk factor (Ekstrand et al, 2011; Ekstrand et al, 2009; Engebretsen et al, 2008; Junge et al, 2002; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). However the study did not report if there were any deficits in vertical jump height or sprint times with the previously injured group, therefore more analysis needs to be undertaken before specific conclusions can be made on the relationship between performance deficits and previous injury history.

Bradley and Portas (2007) researched the relationship between pre-season range of motion and muscle strain injuries in elite football players. It has been reported that 92% of football injuries are to the lower extremities and 18-37% of these injuries are muscle strains (Ekstrand et al, 2011; Ekstrand et al, 2009; Hawkins et al, 2001; Inklaar, 1994;

Ekstrand and Gillquist, 1983), however Bradley and Portas (2007) aimed to establish if range of motion was linked to muscle injuries in football. This study included 36 elite male football players from the same English Premier League team during the 2003-2004 season. The mean player age was 25.6 years and players were excluded from the study if they were currently receiving treatment or had received treatment for a muscle strain in the two months prior to the start of the study. Maximal static range of motion was measured for 6 movements on the dominant and non-dominant lower extremity. The following movements were recorded using 2D video analysis; hip and knee extension and flexion, and ankle plantarflexion and dorsiflexion.

Results showed 32 players sustained a diagnosed lower limb muscle strain injury. The knee flexors had the highest injury rate (29%) followed by the hip flexors (24%), knee extensors (18%), ankle plantarflexors (15%), hip extensors (12%) and ankle dorsiflexors (2%). It was found that those who sustained an injury to the hip and knee flexors had a significantly reduced pre-season range of movement. Limb dominance did not show any significant relationship to injury. This study demonstrates the importance of assessing pre-season range of motion as there was an increase in injury risk for those with a decrease in knee and hip flexor range of motion. However, it must be noted that the muscles were tested through generic range of motion tests and not specific muscle length tests. This meant that individual muscle length reduction could not be identified.

As well as reporting injury epidemiology (section 2.2), Hagglund et al (2012) also reported on lower limb injury risk factors in football. Hagglund et al (2012) found 27% (n=564) of injuries were classed as re-injuries which were identical to the previous injury sustained. The hamstrings (30%) and adductors (29%) had the highest re-injury rates compared to the quadriceps (21%) and calf muscles (21%). Hagglund et al (2012) found adductor and quadriceps injuries occurred more frequently in the dominant leg and the hamstring and calf injuries were evenly distributed between legs.

Heidt, Sweeterman, Carlonas, Traub and Tekluve (2000) researched preseason conditioning and avoidance of injury in female football players as this group are reported to be two times more likely to get injured during football matches than men. Heidt et al (2000) studied 300 female soccer players aged 14-18. Heidt et al (2000) selected 42 of these players randomly and introduced a training programme which concentrated on sport specific cardiovascular conditioning, plyometric work, strength training and flexibility. The training programme was customized to the individual's strengths and weaknesses. Details, however, of the process used for identifying strengths and weaknesses were not given. Results established fewer injuries were sustained in the specifically trained group. Although all injuries cannot be completely prevented, the individually tailored programmes managed to minimise overall injury risk and in particular the number of ACL injuries. In conclusion the study suggested physical attributes such as joint instability, muscle tightness and lack of proper conditioning could increase the risk of injury (Heidt et al, 2000).

Dvorak, Junge, Chomiak, Graf-Baumann, Peterson, Rosch and Hodgson (2000) considered risk factors in 264 male and female football players. They identified approximately 17 risk factors including physical and mental characteristics. Of the physical factors, lack of flexibility and muscular strength, which often lead to muscle imbalance were reported as an injury risk factor. Poor endurance and reaction time were also mentioned as potential physical risk factors. Dvorak et al (2000) also state that the more risk factors identified at initial baseline examination, the higher the likelihood of that player sustaining an injury in the following year. Although these factors are consistent with findings of other studies they have not reported which baseline tests were used to gather this data (Dvorak et al, 2000). Without this information it is not possible to conclude the validity of the tests or data in this study.

Arnason et al (2004) studied male football players to identify injury risk factors in football. A multivariate model was used to review various factors contributing to football injury and to investigate their interrelationship. A total of 306 Icelandic male football players from 17 football teams participated in the study. Each coach was asked to select the 18 best players in their team to be involved in the research. Each participant completed an injury questionnaire and physical testing. The physical tests included peak oxygen uptake, body composition testing (skin-folds), power testing (squat), jump tests (contact mat), flexibility tests (ROM-hamstrings, adductors, rectus femoris and hip flexors) and ankle and knee stability tests (manual ligament stability tests). Injuries were then recorded over the season by the team Physiotherapist using a standardised form. Training and match exposure were also recorded by the coach. Arnason et al (2004) reported a total of 244 injuries sustained by 170 (56%) of the 306 players involved in the study. Lower limb injuries accounted for 82% of all injuries with the thigh being the most frequent (24%), followed by the knee (16%), groin (13%), lower leg (13%) and the ankle (9%) (Arnason et al, 2004). Muscle injuries were the most frequent injury type account for 37% of all injuries.

With regards to risk factors, Arnason et al (2004) reported the injured group to be significantly older and match exposure in the injured group was also higher. Interestingly Arnason et al (2004) reported no overall relationship existing between the injured group and the peak oxygen uptake test, jump tests, and flexibility measures. When broken down into particular injury types, players with higher body fat were more likely to sustain hamstring and groin strains. A lower range of motion for hip abduction was found to be a predictor for new groin strains but hamstring length did not relate to new hamstring injuries. No test variables were found to be statistically related to knee and ankle injuries. Overall previous injury was the strongest predictor of any injury which is consistent with previous studies (Ekstrand et al, 2011; Ekstrand et al, 2009; Engebretsen et al, 2008; Junge et al, 2002; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983).

The literature has identified that previous injury is a risk factor for injury in football (Ekstrand et al, 2011; Engebretsen et al, 2008; Emery et al, 2005; Junge et al, 2002). Interestingly, there is conflicting evidence with regards to muscle tightness as a risk factor for injury. Although Heidt et al (2000) reported muscle tightness could increase a player's risk of injury, this was not directly proven in their study. Witvrouw et al (2003) specifically investigated flexibility in relation to muscle injuries and found that only hamstring injuries were linked to reduced hamstring flexibility but adductor, quadriceps and gastrocnemius muscle length were not related to muscle injury rates. These findings suggested isolated muscle length tests are not a predictor of muscle injuries and highlight alternative screening methods are necessary. Croisier et al (2008) reported quadriceps to hamstring muscle imbalances that were left untreated also increased injury risk, showing the importance of assessing muscular strength. This was reinforced by Lehance et al (2008) who found players with strength deficits reported previous injuries. Engebretsen et al (2010a, 2010c, 2010d) concur that previous injury is a predictor of groin, hamstring and ankles injuries but found no relationship to injury with plinth based ankle and knee stability tests and the single leg stand for balance. Therefore it is important that a screening tool is able to assess muscular strength, balance and flexibility in a dynamic way that represents the demands of the sport being played.

2.4 FIFA Medical and Research Council (F-MARC)

In 1994 the FIFA Medical and Research Council (F-MARC) was founded to promote and protect the health of football players and to encourage football as a healthy & safe leisure activity (FIFA, 2010). F-MARC has had a number of objectives over the years with reducing injury incidence in football being of top priority. Other objectives have included but are not limited to prevention of sudden cardiac death, education on heat and altitude training and optimisation of nutrition during Ramadan (FIFA, 2010). Published material has been devised for players, coaches, Physiotherapists and Doctors. Recently, F-MARC published a document which reviewed their projects over the last 15 years, including research on injury epidemiology, screening and injury prevention (F-MARC, 2009).

2.4.1 F-MARC Screening in Football

In 2000, F-MARC acknowledged screening procedures are commonly carried out in the football environment. These procedures are often individualised to the specific club and may not be available for public access. As there is not a single test battery that is accepted world-wide for football, Rosch et al (2000) set out to develop a standardised profile in men's football. The research was conducted in conjunction with F-MARC and the profile is known as the F-MARC test battery. Using 588 male subjects they aimed to develop a standardised profile to initially evaluate physical performance in football. The tests used were designed to reflect normal football activity such as flexibility, football skills, power, speed and endurance (Rosch et al 2000). A secondary aim of their study was to assist Physiotherapists with screening. Rosch et al (2000) believe profiling helps to identify the player's physical attributes which can help with injury prevention and monitor progress during injury rehabilitation. They did not use any complicated lab procedures which allows this test battery to be performed on the field and in less developed and resourced environments. This is important as only a small percentage of footballers play at an elite level (Engebretsen et al, 2008). The majority of football players either play semi-professionally or recreationally, therefore advanced resources are not readily available for the vast majority of players. This strengthens Rosch et al's (2000) argument for using in-expensive, reliable tests.

Rosch et al's (2000) results demonstrated support for injury screening and were able to establish normative values for joint range of movement in male football players and also reported being able to effectively evaluate training effects. The sample size was large; however specific on the sample population was not given making it difficult to transfer to other populations. There is also no data available with regards to injury prediction in relation to the F-MARC test battery. The profile also takes two and a half hours to perform which is longer than normally recommended to maintain a player's interest and compliance (Blanch, 2005). However, Rosch et al (2000) acknowledged the length of time for the protocol was developed to mimic football match time.

Importantly, there is little evidence to show how the F-MARC test battery has been distributed and implemented in football. No follow up studies were found on the use of the F-MARC test battery in evaluating performance or injury prediction in football. Although a brief summary of the F-MARC test battery can be found in the report of the 15 years of F-MARC Research and Education (F-MARC, 2009), the test battery does not appear in the F-MARC Football Medicine Manual (2009). This is surprising as the F-MARC Football Medicine Manual (2009) has a section on injury prevention which includes a general orthopaedic assessment and performance assessments. Therefore is may be concluded that the F-MARC test battery has not been widely adopted in the football community.

2.4.2 F-MARC Injury Prevention

In alignment with F-MARC's injury prevention aims, Junge et al (2002) investigated the effects of an injury prevention programme on the incidence of injuries in amateur male youth soccer players with support from F-MARC. A total of 194 players' data was recorded in this study, 87 who were considered high-skill and 107 who were classed as low-skill players. Of the participants, 101 were allocated to an intervention group and 93 into a control group. The allocation process was not detailed but the authors reported the groups to be comparable at baseline testing. Specific baseline testing details were not given in this article, but the reader was directed to a subsequent reference for testing information (F-MARC Test Battery Manual, 1997). The tests were described by Junge et al (2002) as a clinical examination of the spine, hip, knee and ankle plus specific soccer tests of flexibility, speed, strength and endurance that had been modified from another reference. A self-reported questionnaire on medical history, psychological characteristics and playing and training details was also obtained. Those who were allocated to the intervention programme received both a generic exercise regime and an advised individual exercise programme based on the results of the baseline testing. No specific details were given on the prevention programmes but the authors made reference to football specific literature that was accessed to devise the programmes.

Junge et al (2002) reported 20% less injuries in the intervention group that completed an injury prevention programme. In particular there were 30% less overuse injuries in the intervention group. It was also found that low-skilled players in the intervention group had 37% less injuries than low-skilled players in the control group but high-skilled players only had 6% less injuries than their counterparts in the control group. The study successfully demonstrated that in youth amateur male soccer players, injuries can be reduced through introduction of an injury prevention programme. This was especially evident in lower skilled players. This study has stated that it used soccer specific baseline testing which supports the need for sports specific screening tools. However it fails to describe these tests in detail. It must be pointed out that the results may not transfer to adult or professional soccer players but it does give indications for the need for further research on sport specific functional testing.

To further assist with injury prevention, F-MARC developed the FIFA 11 and subsequently the advanced FIFA 11+ to help reduce the amount of injuries sustained in football by providing a set of standardised football specific exercises (F-MARC, 2009). F-MARC recommends the exercises are performed before every training session which takes approximately 20 minutes and a shortened version should also be performed before every match (F-MARC, 2009). Interestingly the FIFA 11+ exercises were introduced by FIFA as they claimed scientific evidence had shown a 30-50% reduction in injuries (F-MARC, 2009).

When the evidence which is referred to was reviewed, limitations must be acknowledged. Information on the selection of the standardised exercises in the FIFA 11 and FIFA 11+ is lacking. Literature suggests they were selected based on evidence or best practice but there is no reference to the supporting evidence for each test included. The panel which devised the exercises are also not described in any detail. Reference is made to a group of internal experts from the Oslo Sports Trauma Research Centre and the Santa Monica Orthopaedic and Sports Research Foundation who developed the exercises under the guidance of FIFA and F-MARC (F-MARC, 2009). There was no justification for the panel members included and it is not known if they were Physiotherapists, Doctors, Sports Scientists, Coaches or from a combination of disciplines.

In addition, gaps in knowledge specific to evidence showing injury reduction following implementation of the FIFA 11+ still remain. The first piece of work F-MARC used to encourage the use of the FIFA 11+ was a study performed by Soligard, Myklebust, Steffen, Holme, Silvers, Bizzini, Junge, Dvorak, Bahr and Andersen (2008). Soligard et al (2008) did report a significant reduction in overall injuries; however, lower extremity injuries, ankle injuries and knee injuries did not show a significant reduction following implementation of the FIFA 11+. It also must be acknowledged that although Soligard et al (2008) did use an intervention group and a control group and involved a large sample size of 1,892 women from 93 clubs, they were adolescent females between the ages of 13-17yrs old. Literature has demonstrated different injury incidence in not only males and females but also in adolescents versus adults (Alentorn-Geli, Myer, Silvers, Samitier, Lazaro-Haro and Cugat, 2009; Merron, Selfe, Swire and Rolf, 2006). Therefore the results of the study are only transferrable to adolescent female football players.

In 2004-2008, Junge, Lamprecht, Stamm, Hasler, Bizzini, Tschopp, Reuter, Psych, Wyss, Chilvers and Dvorak (2010) under the direction of F-MARC studied the implementation and effectiveness of reducing football injuries country wide in Swiss amateur players. Interestingly the FIFA 11 was used and there was no explanation why the revised FIFA 11+ had not been implemented. In Switzerland licensed coaches are required to attend a refresher course every 2 years therefore the instruction of the FIFA 11 was incorporated to the coaches' education day. In total 5,549 coaches were instructed on the FIFA 11 but it is not known how many of these coaches implemented the FIFA 11 exercises as only a selection were interviewed in this study in both 2004 and 2008. The total number of coaches interviewed was not clearly stated by Junge et al (2010).

Of the coaches who were interviewed 80% reported knowledge of the FIFA 11 campaign and 57% of coaches acknowledged they had implemented the exercises or at least most of them. Coaches who reported using the FIFA 11 had an 11.5% lower incidence in match injuries and a 25.3% lower incidence in training injuries. It was also reported that there was a reduction in non-contact injuries by up to 27%. However, it is difficult to interpret these percentages as exact numbers have not been provided. Junge et al (2010) also state that 57.4% of coaches reported varying the exercises therefore losing the standardisation of the programme. Additional training methodologies employed by coaches were also not acknowledged. More importantly a number of flaws exist in the collection of injury incidence data. Firstly, pre-intervention interviews were conducted with coaches, not medical professionals and coaches were asked to re-call the injuries in the last match and give the interviewer details of each injury. This was repeated going backwards in chronological order for 4 weeks. Therefore re-call bias and limited knowledge of injury types and classifications may have affected the accuracy of the results. Considering the number of coaches interviewed is not clear, the injury data provided is not reliable and over half of the coaches reported varying the FIFA 11 exercises, results showing a reduction in injury incidences should be interpreted with caution.

More recently Steffen, Emery, Rometi, Kang, Bizzini, Dvorak, Finch & Meeuwise (2013) studied the implementation of the FIFA 11+ exercises in 226 adolescent (13-18yrs) female football players during the 2011 season. A total of 29 teams were randomly allocated to three intervention groups; control (n=9), regular (n=10) and comprehensive (n=10) programmes. The coaches in the control group were given access to the FIFA 11+ website only, the coaches in the regular group attended 1 training session and were provided with FIFA 11+ material and the comprehensive group were assigned a Physiotherapist who taught & monitored the exercises with the team. Prior to the start of study, all players were assessed on single-leg balance eyes closed on an airmax balance pad, the Star Excursion Balance Test, single-leg triple hop and jump of a bar test.

Interestingly results revealed the Star Excursion Balance Test results improved the most in the comprehensive group but the number of jumps over the bar improved more in the control group. The study also found little difference in performance variables between groups and instead reported better results were observed in players with a higher adherence rate. These benefits included lower injury risk & improved balance performance which Stefffen et al (2013) suggests will further reduce a player's risk of injury. However it must be noted that there was not an intervention group that did not complete the FIFA 11+ exercises; the study was only investigating the different levels of instruction on the programme. Again, as seen in Soligard et al (2008) the results are only applicable to adolescent females but nonetheless provide further supporting evidence that the FIFA 11+exercises can reduce injury risk.

Impellizzeri, Bizzini, Dvorak, Pellegrini, Schena & Junge (2013) examined the effects of an injury prevention programme on performance, strength and neuromuscular control in Italian male amateur football players. Impellizzerri et al (2013) used a randomised control method to allocate players to either a control (n=39) or FIFA 11+ (n=42) group. The control group completed their normal standardised warm-up over 9 weeks while the FIFA 11+ group performed the exercises 3 times per week for 9 weeks. All players were examined at baseline on the following tests: time-to-stabilisation, eccentric/concentric knee flexor and extensor strength, Star Excursion Balance Test, core stability, vertical jump height, sprint speed & agility.

Results of the study found time-to-stabilisation, core stability and flexor strength significantly improved in the FIFA 11+ group. However no significant differences were found with the Star Excursion Balance Test, vertical jump, sprint and agility tests. Impellizzeri et al (2013) therefore concluded that performing the FIFA 11+ exercises 3 times per weeks for 9 weeks improves time-to-stabilisation and neuromuscular control which in turn may reduce the risk of injury. However this study only looked at the training effect of the FIFA 11+ and cannot definitely say the programme does indeed reduce the risk of injury.

Grooms, Palmer, Onate, Myer and Grindstaff (2013) examined the effects of the FIFA 11+ programme on lower extremity injury rates. Over two seasons, 41 players were studied with season one (2009) acting as a control season and season two (2010) the intervention season. In season one, players performed their normal warm up and in season two the FIFA 11+ exercises were introduced to replace the existing warm up.

Grooms et al (2013) reported a reduction in injury rates from 2009 (8.1/1,000 hrs) to 2010 (2.2/1,000hrs) after implementing the FIFA 11+ exercises. In total, days lost reduced from 291 days in the control season to 52 days lost in the intervention season. This translates to a 72% reduction in lower extremity injury risk. However, it must be noted that a low number of injuries occurred in both seasons; 13 injuries in 2009 and 4 injuries in 2010. No ACL or ankle sprains occurred in either season therefore the effect on reducing these injury sub-types is unknown. Although the study does support the FIFA 11+ in injury reduction, in particular muscle injuries, only 41 players were studied which is a small sample size. However, it does provide supporting evidence in the male adult population.

Bizzinni, Junge and Dvorak (2013) discussed the implementation and dissemination strategy of the FIFA 11+ exercises in an informative article. Since 2009 FIFA has been actively working to disseminate the FIFA 11+ world-wide. This has been done through targeting member associations, developing the 11+ materials, offering workshops to coaches and supporting research projects evaluating the programme. The coach was identified as a key person to promote injury prevention and Bizzinni et al (2013) report it to be imperative to motivate and educate coaches on injury prevention. Sports Physiotherapists have also been identified as crucial players in implementing the programme as they understand the need for injury prevention. As increasing evidence is supporting the effectiveness of the programme and shown a reduction in costs associated with injury, FIFA plan to continue with world-wide dissemination. Through evaluating the strategies used since 2009, getting the member associations to adopt and endorse the programme is of top priority as this has shown the best results in compliance with the programme.

2.4.3 Conclusion of F-MARC Research

Despite F-MARC having clear research aims, the literature that has been published does not inter-link these themes. Although the F-MARC testing battery was designed for use in football, at this time it only provides normative values for player comparison and individual baseline data (Rosch et al, 2000). To date there is no known data comparing F-MARC baseline information to injury rates therefore it cannot be used to predict injury in football. Furthermore the F-MARC test battery does not appear in the most recent version of the FIFA Medicine Manual (2009) and did not appear to be consulted in the development of the FIFA 11/11+ exercises. As well as this, the literature supporting implementation of the FIFA 11/11+ has largely been carried out on adolescent females. Only a limited amount of studies into the male population and different levels of play exist therefore further research is still needed. In addition the need for a consistent screening protocol that can be used to monitor the effectiveness of injury prevention programmes has been identified.

2.5 Screening in Football

With the lack of standardised and accessible screening procedures still existing in football, Frohm, Heijne, Kowalski, Svensson, and Myklebust (2011) investigated the reliability of a nine-tests screening battery for elite male footballers. In their study they screened 18 male elite footballers on nine functional tests from tests which had been used in the literature over the last 10 years. Six of the tests came from the Functional Movement Screen (Cook, Burton, and Hogenboom, 2006a; Cook, Burton, and Hogenboom, 2006b; Cook, 2003), one from the United States Tennis Association and two tests that the group selected and standardised themselves. Eight Physiotherapists were present in the same room and scored the athletes performing the nine tests.

Frohm et al (2011) reported good intra and inter-rater reliability from the study, however many factors were not taken into consideration. Firstly, all 8 Physiotherapists worked in the same clinic and received the same training. They were also involved in standardising two of the tests included in this protocol. Therefore it is not possible to conclude if someone who was unfamiliar with the test protocol would score it similarly to someone with knowledge or another novice user. Another key issue is the selection of the tests included in the protocol. The authors do not give any indication as to why they selected each specific test or how that test is related to football. Instead the authors simply stated that they chose from tests in the literature that have been tested and re-tested over the past 10 years. Of the 9 tests selected, 6 came from the Functional Movement Screen which was not developed specifically for football and one test from tennis. There is no justification as to why they would be useful in a football screening tool. Finally, all tests were scored using a modified system based around a scale developed by Cook (2003) which rates a movement from 0-3. Again, the authors do not mention why they used this scale and why they modified the original scale. The authors also failed to discuss what research currently is available on scoring functional movements. Without justification for the tests inclusion and modification of the scoring system, it is difficult to know if this tool is appropriate for football despite showing good inter and intra-rater reliability. It must also be noted that Frohm et al (2011) did not report on the screening tool's ability to predict injury at this stage and further studies on injury prediction were not found in the literature.

2.5.1 Performance, Power and Strength Screening in Football

Requena et al (2009) examined performance, power and strength in football players to investigate if the tests met the dynamic demands of the game. In particular Requena et al (2009) highlight how open kinetic chain isokinetic measures are often used in football to determine strength but acknowledge this may not represent functional strength which often involves more closed kinetic chain activity or a combination of both. Therefore Requena et al (2009) aimed to compare isokinetic and isometric strength against 2 functional performance tests. A total of 21 male Estonian semi-professional football players were studied with a mean age of 20 years. All players trained 2-4 hours per day; playing experience ranged from 12-15 years. For the year prior to the study, all players were reported to have undertaken continual resistance training programmes that included both strength and power. Half squats were used to determine 1Rep Max (1RM) and maximal peak power output. Isometric maximal force of knee extensors and plantar flexors was recorded as well as isokinetic peak torque of the knee extensors. Functional tests included vertical jump height from a squat jump and counter movement jump and 15m sprint time.

Results of the study found that 1RM of the half squat measuring maximal power output was related to vertical jump height and sprint time. However, a low to non-significant correlation was found between functional and performance test results in relation to isometric and isokinetic strength measures. Requena et al (2009) report these findings to be consistent with previous studies (Wisloff et al, 2004). Importantly these results show isolated open kinetic chain isometric and isokinetic strength tests do not replicate results found in functional performance tests. Therefore it calls into question the use of isolated isometric and isokinetic testing in dynamic sports. However, it must be acknowledged that this study only looked at correlations and relationships of variables; it did not present cause and effect data.

2.5.2 Orthopaedic Screening in Football

Before the 2006 FIFA World Cup, Junge, Feddermann and Dvorak (2009) evaluated the viability of implementing an orthopaedic component into standardised pre-competition medical assessment (PCMA). The PCMA standardised assessment and data recording forms were developed specifically for the 2006 World Cup and the methodology is described in a concurrent study (Dvorak, Grimm, Schmeid and Junge, 2009). Team Doctors were asked to complete an orthopaedic examination on all players within their teams on the standardised PCMA forms. This included questions on injury history, previous operations due to a football injury and any current musculoskeletal complaints. The physical exam followed the orthopaedic assessment procedure outlines in the FIFA Football Medicine Manual (2009) and assessed the ankle and foot, lower limb, knee, hip, thigh and groin. The forms allowed for a range of motion figure to be inserted or for the Doctor to tick normal or pathological. Free text could be inserted at the Doctors own discretion, for instance to add any additional notes or diagnosis. Cardiovascular screening was also assessed but will not be discussed in this review as it is not relevant to the current thesis. Of the 32 teams involved in the 2006 World Cup, 26 teams (75%) returned the PCMA forms. This resulted in complete and partial data being collect from 553 players, although no figure was provided for a breakdown of how many complete data sets were recorded. Junge et al (2009) reported overall a high rate of completion for the orthopaedic section but acknowledged the section with the lowest completion rate, less than 20%, to be the assessment of range of motion of hip and knee flexion and extension. Junge et al (2009) concluded this was due to variations in normal range of motion assessments with each team and that clearer instructions needed to be provided.

Junge et al (2009) reported players from all teams to have a similar range of motion for hip internal and external rotation and abduction. Flexibility of the hamstrings, adductors, iliopsoas and rectus femoris were reported to be normal in both legs for the majority of players (95-99% of players). Knee and ankle stability through clinical examination were also reported as normal for nearly all players (97%-99%). Interestingly, previous injury history was collected but prospective injury data was not collected alongside the PCMA in the 2006 World Cup in this study. Therefore the study was only able to conclude on the feasibility of implementing a standardised PCMA and the compliance rates amongst Doctors. It would have been more beneficial to have information on injuries sustained during the World Cup to compare against the PCMA data to potentially identify injury risk factors.

Frohm et al (2011) have developed a screening tool for football but have only reported on the intra and inter tester reliability. There is no information on the tool's ability to predict injury in football. Despite a lack of injury prediction data, Frohm et al (2011) and Rosch et al (2000) identify the importance of screening tools replicating specific sporting movements and are easy to administer in the field. Importantly, Requena et al (2009) identified that isometric and isokinetic strength in football players did not correlate with performance on functional tests; therefore questioning the relevance of expensive open kinetic chain isokinetic and isometric testing in dynamic sports. Junge et al (2009) identified a 75% compliance rate with using a standardised PCMA in the 2006 World Cup. Although the PCMA was not used to establish injury prediction markers in football, it shows good potential for Doctors to utilise a standardised assessment.

2.6 Functional Screening in Sport

2.6.1 Lower Limb Functional Screening

Functional screening is becoming common practice in many sports. Dallinga, Benjaminse and Lemmink (2012) performed a systematic review of screening tools that can be used to predict lower limb injuries in team sports. The review was conducted as team sports, such as football, involve a number of lower limb injuries and Dallinga et al (2012) believe development of screening tools can assist in injury prediction and prevention. Dallinga et al (2012) also state that screening tools should be low in cost, simple and able to be used in large scale clinic or field environments. Dallinga et al (2012) used a search strategy that included articles from 1966-September 2011 and they followed a set inclusion criteria and methodological ranking scheme. This was applied to each of the 128 potential studies identified but only 23 studies met the full inclusion criteria for the review.

The main findings from the systematic review found most screening tools examined injury prediction for a specific type of injury, not for a specific sport. Tests for ACL injuries, knee, hamstring, groin and ankle screening tools were located along with groups of screening tools being identified. Dallinga et al (2012) classified these groups as anthropometric tests, flexibility/range of motion tests, balance tests and ACL injury prediction tests. Within each of these groups some functional tests were reported but this was not consistent throughout. The systematic review helped to identify tests which may predict specific injuries, therefore combined with epidemiological data on injuries in relation to specific sport; this could help to develop a sport specific screening tool.

2.6.2 Functional Screening in Gymnastics

Functional screening in Gymnastics is essential for achieving injury-free participation and for assessing physical competitive fitness (Sleeper, Kenyon and Casey, 2012; Sleeper and Casey, 2010). The Gymnastic Functional Measurement Tool (GFMT) has been designed to examine a gymnast's overall fitness level with some relation to gymnastic skills (Sleeper et al, 2012). The GFMT incorporates flexibility, speed, power, strength, muscular endurance and balance by using tests that were found in the literature for gymnastics and confirmed by experts in the field (Sleeper and Casey, 2010). As the GFMT is currently used in gymnastics, this study aimed to review the construct validity and scoring of the tool.

Sleeper et al (2012) recruited 105 gymnasts ranging from 6-18 years old to complete the GFMT. Fifty-one of these athletes were asked to attend a second testing using the same tool. Overall the GFMT score was found to be positively linked to their current level of gymnastics participation. This study did not examine injury rate but as functional and fitness deficits were identified with the GFMT the authors suggested this topic as the next progression in the further development of this tool.

2.6.3 Functional Screening in Dance

In dance, functional screening has been carried out and shown interesting results. In 2006, Steinberg, Hershkovitz, Peleg, Dar, Masharawi, Heim and Siev-Ner profiled 1,320 female dancers and 226 non-dancers. The main component of their testing was assessment of the range of movement of the hip, knee, ankle, foot and spine which are important for functional dance movements. In this study, they found dancers over time maintained ankle and foot plantar flexion and hip external rotation but had a reduction in hip abduction as they aged. From this they recommended that dance teachers should focus on maintaining natural functional dance flexibility as opposed to trying to increase the range of motion. This study carries the advantage of both a control and non-control group, however it is unclear as to the time frame in which the subjects were retested (Steinberg et al, 2006). This study has similar themes as to a prior study carried out by Hamilton, Hamilton, Marshall and Molnar (1992) on ballet dancers. Even though the sample size was smaller, 28 dancers, again they assessed joint range of movement. In addition to this, they also profiled a combination of men and women, 14 of each. They reported that women during their dancing years had an increase in hip external rotation and decreased internal rotation which is the exact opposite of men. From this data, they were able to make suggestions to areas which the dancers need to concentrate on improving (Hamilton et al, 1992).

Wilson and Deckert (2009) explored the feasibility of implementing a combined screening programme into a dance kinesiology class. The purpose of the tool was to assess body alignment and functional symmetry through observations, active and passive range of movement, dance movements, flexibility and strength. A medical and previous injury questionnaire was also completed. The active component of the tool combined isolated and functional tests as both components are important in dance (Wilson and Deckert, 2009). Twelve students volunteered to be screened using the dance specific tool, 9 females and 3 males. Results found isolated and functional deficits could be identified through combined testing. Results also demonstrated that corrective exercise could be taught if limitations or risk factors were identified. However, the study did not give specific information on the deficits found therefore results can only be used to highlight that a combined screening approach may be necessary.

2.6.4 Functional Screening in Australian Rules Football

Functional and musculoskeletal screening has also been performed in Australian Rules football (Gabbe, Finch, Wajswelner and Bennnel, 2004). Gabbe et al (2004) examined 126 male players prior to a new season. Measures of height, weight, BMI, joint range of movement in the hip, lumbar spine and ankle flexibility were recorded by three experienced testers. Standard measurement tests were documented step by step to increase reliability and repeatability. The result showed reduced ankle flexibility and an increase in age to be the risk factors of lower limb injuries (Gabbe et al 2004). Surprisingly, hip range of movement did not appear to be related to lower limb injuries but the data collected on ranges of movement were used to establish normal joint ranges for Australian Rules players (Gabbe et al 2004). By establishing normative values and tests that identified functional deficits, potential injuries may be able to be reduced. However, despite the study suggesting function was also being assessed, most tests used were from a more classic musculoskeletal background. Further functional tests need to be considered in this sport.

2.6.5 Functional Screening in Jogging

Whatman et al (2011) acknowledge the need for functional screening in sport and dynamic activity. In their study they examined 25 participants with a mean age of 22 years, on 5 lower extremity functional tests to investigate the relationship of these tests to jogging kinematics. Data was recorded with a 3D, 9 camera motion analysis system using 15 reflective marks on the lower limbs and trunk. The functional tests included were small knee bend, single-leg small knee bend, lunge, hop lunge and step down.

Of the 5 functional tests, small knee bend had the highest association with jogging kinematics. The other tests are reported to have moderate to strong associations but exact figures are not stated. Although this study does not prove that functional tests replicate jogging kinematics it provides building blocks for ensuring functional tests used in sport have been tested against the kinematics used in sport. At present, this appears to be lacking in football.

2.6.6 Functional Screening in Sport & Specific Work Related Tasks

Mottram and Comerford (2007) developed the performance matrix to bridge the gap between standard non-functional musculoskeletal assessment and functional assessment in sport and specific work related tasks. Mottram and Comerford (2007) identified that there is little reliable evidence to support that screening has predicted injury risk and subsequently prevented injury in sport. Mottram and Comerford (2007) highlight that there are currently few studies that have assessed true function which examines multiple muscle interactions over multiple joints during functional tasks. Specifically information on low and high loading thresholds during functional activity has not been explored. This is important for potentially identifying a weak link during uncontrolled movement within a chain of linked joints in multi-joint functional tasks (Mottram and Comerford, 2007). To assess multi-joint function, Mottram and Comerford (2007) developed the performance matrix of high and low threshold tests to motor control and kinetic chain linking through functional multi-joint tasks. The performance matrix included 10 testing categories and is designed to identify weak links through a series of yes or no questions relating to the performance of the movements. The tests were classified into 5 high threshold and 5 low threshold tasks. The low threshold tests include; standing small knee bend, sitting spinal dissociation, standing arm control, crook lying limb control, hand & knees limb control. The 5 high threshold tests were crook lying limb loading, modified push up, standing shoulder loading, lunge loading and explosive propulsion.

Mottram and Comerford (2007) raise valid points with regards to there being limited research assessing true functional movements. However, the performance matrix website states it has been “tried and tested” but no studies were found that evaluated the performance matrix’s ability to predict injury in sport. Mottram and Comerford (2007) present an informative article identifying tests which may be used to predict injury in sport but no evidence exists to support this claim. The performance matrix has now been adapted specifically for different sports, including football. The performance matrix brands itself as the “movement control specialists” and states it will minimise player injury risk and maximise performance (Performance Matrix, 2014). Furthermore, the football performance matrix is not a free resource; software must be purchased or training course attended, costing between £250-850.

2.6.7 Conclusion of Functional Screening in Sport

Dallinga et al (2012) identified that there are tests which are capable of predicting specific injuries but they are not sport specific at present. Sleeper et al (2012) successfully used a method of reviewing current literature and using a panel of field experts to develop a functional screening tool for gymnastics. Whatman et al (2011) demonstrated that understanding the kinematics of a sport is essential for selecting injury prediction tests that replicate the demands of the sport. Although Mottram and Comerford (2007) provide a substantial argument for the need to perform functional tests in sport, the performance matrix lacks evidence supporting its ability to prevent injury in sport and in particular in football. Overall the importance of functional screening in sport is well justified but gaps in knowledge still exist. Sleeper et al’s (2012) methodology could serve as a guide for developing sport specific screening tools through combining the use of field experts and current evidence found in the literature.

2.7 The Functional Movement Screen (FMS)

Cook et al (2006a) and Cook et al (2006b) explored the use of fundamental or functional movements as a part of a pre-participation screening focussed on assessing function. In this paper key concepts around screening were discussed. Cook et al (2006a) and Cook et al (2006b) state the importance of functional tests to assess the ability to perform essential movements that are specific to an activity or sport. They discussed the idea of moving from traditional and isolated tests to tests that are fit for purpose. Therefore the authors put forward the Functional Movement Screen (FMS). This was one of the first protocols to be used world-wide with athletes participating in various sports and at various levels of competition (Okada, Huxel and Nesser, 2011; Chorba, Chorba, Bouillon, Overmyer and Landis, 2010; Kiesel et al, 2009).

The Functional Movement Screen was developed on the principles of proprioception and kinaesthetic awareness. These are essential for kinetic-linking in the body (Cook et al, 2006a; Cook, 2003). Cook et al (2006a) report the segments of the body work in a specific sequence from proximal to distal in order to achieve a specific desired action distal to the segment. Therefore tests in functional screening need to reflect these principles. The screening tool consists of the following 7 tests (Table 3, p44): overhead squat, in-line lunge (right & left), rotary stability (right & left), shoulder mobility (right & left), trunk stability push-up, hurdle step (right & left) and active straight leg raise (right & left). Each movement is scored from 0-3 with 0 being given if pain is present anywhere in the body during the movement, 1 is given if the athlete is unable to complete the movement or unstable during completion of the movement, 2 is given if the athlete is able to complete the movement but with compensation and finally a 3 is given for correct execution of the movement (Cook et al, 2006a; Cook et al, 2006b). Each test is performed 3 times and a total score of 21 is the highest score that can be achieved. Although a number of the tests are scored for left and right sides, only the lowest score from the two sides is recorded (Cook et al, 2006a; Cook et al, 2006b; Cook, 2003).

Table 3-The Functional Movement Screen (FMS) adapted from Cook (2003)

Test	Illustration	Score 3	Score 2	Score 1
Deep Squat Assesses bilateral symmetrical & functional mobility of the hips, knees & ankles		• Upper torso is parallel with tibia or toward vertical • Femur below horizontal • Knees are aligned over feet • Dowel does not extend past feet	• Performed with heels on 2x6 board • Same criteria as 3-pt scale	• Tibia and upper torso are not parallel • Femur is not below horizontal • Knees are not aligned over feet • Lumbar flexion is noted
In-Line Lunge Assesses torso, shoulder, hip, knee & ankle mobility and stability & quadriceps flexibility		• Dowel contact remains with L-spine extension (dowel touches head, T-spine & sacrum) • No torso movement is noted • Dowel & feet remain in sagittal plane • Knee touches board behind heel of front foot	• Dowel contacts do not remain with L-spine extension • Movement is noted in torso • Dowel & feet do not remain in sagittal plane • Knee does not touch behind heel of front foot	• Loss of balance is noted • Inability to place hands in proper position
Hurdle Step Assesses bilateral functional mobility & stability of the hips, knees & ankles		• Hips, knees & ankles remain aligned in the sagittal plane • Minimal to no movement is noted in the lumbar spine • Dowel & hurdle remain parallel • Foot remains dorsiflexed	• Alignment is lost between hips, knees & ankles • Movement is noted in lumbar spine • Dowel & hurdle do not remain parallel	• Contact between foot & hurdle • Loss of balance is noted
Shoulder Mobility Assesses bilateral shoulder range of motion, internal rotation & adduction and external rotation & abduction		• Fists are within one hand length	• Fists are within one and a half hand lengths	• Fists are not within one & a half hand lengths • Clearing assessment was conducted
Straight Leg Raise Assesses active hamstring & gastroc-soleus flexibility while maintaining a stable pelvis & active extension of the opposite leg		• Ankle and dowel resides between midthigh & ASIS • Opposite hip remains neutral (does not externally rotate), toes remain pointing up • Knees remain in contact with board	• Ankle & dowel resides between midthigh and mid-patella	• Ankle & dowel resides below mid-patella
Trunk Stability Push Up Assesses trunk stability in the sagittal plane while a symmetrical upper-extremity motion is performed		• Men perform 1 repetition with thumbs aligned with forehead • Women perform 1 repetition with thumbs aligned with chin • Body is lifted as one unit (no lag in L-spine) • Feet remain dorsiflexed	• Men perform 1 repetition with thumbs aligned with chin • Women perform 1 repetition with thumbs aligned with clavicle • Body is lifted as one unit (no lag in L-spine) • Feet remain dorsiflexed	• Men are unable to perform 1 repetition with thumbs aligned with chin • Women are unable to perform 1 repetition with thumbs aligned with clavicle • Clearing assessment was conducted
Rotary Stability Assesses multi-plane trunk stability during a combined upper and lower extremity motion		• Performs 1 correct unilateral repetition while keeping spine parallel with board • Knee and elbow touch in line over the board • Minimal trunk flexion	• Performs 1 correct diagonal repetition while keeping spine parallel with board • Knee and elbow touch in line over the board	• Inability to correctly perform one diagonal repetition • Clearing assessment was conducted

Throughout the article Cook et al (2006a) describe the purpose, test procedure, scoring system and clinical implications of each of the seven tests included in the Functional Movement Screen. Interestingly, only two references are mentioned in the section which gives details about the tests. The other twenty four references in the article are found in the introduction and summary. Therefore most of the information about the tests is un-referenced. There appears to be little evidence to show why they have selected a specific test, how they developed the test instructions and scoring system. The tool appears to link to the athletic population but there is little rationale behind why these tests are suitable for different sports.

2.7.1 Core Stability, Performance and the Functional Movement Screen

Okada et al (2011) investigated the relationship between core stability, performance and functional movement. As core stability allows optimal control of force, transfer and motion, it is essential in integrated kinetic chain activities. Okada et al (2011) highlight the importance of maintaining stability and mobility along the kinetic chain during functional movement patterns. In their study, 28 healthy men and women with a mean age of 24.4 years were tested on 4 core stability tests, 7 functional movement tests from the FMS and 3 performance tests. Performance tests included the backward overhead medicine ball throw, T-run agility test and the single test squat test. Participants involved in this study were recreational athletes from varied un-stated sports backgrounds.

Results of the study showed there was a significant correlation between the FMS tests and performance tests. In particular the backward overhead medicine ball throw showed a positive correlation with the hurdle step, trunk stability push up and rotational stability tests. The performance tests also showed a positive correlation with the core stability tests. However, interestingly none of the FMS tests demonstrated any significant correlations with the core stability tests. Due to this unexpected finding, Okada et al (2011) postulated that the core stability tests used were isometric and therefore dynamic core stability tests may have been found to have more of a link to the FMS tests. Another limitation to this study is that the full FMS scores have not been provided making it difficult to establish the baseline FMS performance for this group. This appears to be consistent with other studies which found that individuals who scored lower on the FMS had poor performance and elevated injury risks (Chorba et al, 2010).

Parchmann and McBride (2011) studied the relationship between the FMS and athletic performance as little literature currently exists linking the FMS to specific sports performance and skills. Parchmann and McBride (2011) examined 25 American National Collegiate Athletic Association (NCAA) Division 1 golfers. The group consisted of 10 women and 15 men with a mean age of 20.5 yrs and 20 yrs respectively. All participants completed a 1RM squat, 10- and 20m sprint, vertical jump test, T-test completion time, club head velocity swing and the FMS over 3 testing sessions. The results of this study not only showed that there was no relationship between the total FMS score and performance variables, it also showed that there were no relationships between individual FMS tests and performance tests assessed in this study. These results contradict the results of Okada et al (2011) who did find a relationship between certain FMS tests and performance tests. However, it must be noted that Parchmann and McBride's (2011) study is specific to golf and the performance indicators used in this study such as vertical jump and sprint times are not directly related to everyday golfing skills. It would be of interest for the same procedure apart from the club head velocity swing to be analysed in more dynamic sports such as football as this data does not currently exist in the literature.

2.7.2 Normative Values on the Functional Movement Screen

As the Functional Movement Screen is becoming increasingly popular in the sporting environment, Schneiders et al (2011) decided to conduct a study that identified normative values in a young and athletic population. In addition to this they wanted to evaluate if men and women performed differently on the functional movement screen, if previous injury influenced screening scores and to evaluate inter-rater reliability of the functional movement screen.

Two hundred and nine subjects between 18 and 40 years of age living in southern New Zealand completed the study. In order to participate, subjects were required to take part in regular physical activity at any level. No definition as to what qualified as regular activity was given. Subjects who had sustained an injury over the last six weeks were excluded from participation. Two Physiotherapists collected the data on all participants. The two Physiotherapists had previous in-house training on the use of the Functional Movement Screen and they also had access to a training video on administering the Functional Movement Screen. Details were provided on the origin of the training video. Each participant performed each test three times and the highest score was recorded.

Of the 209 participants in the study, there was a nearly equal gender split with 108 females being tested and 101 males. Ages were similar with mean for the females 21.2 years and men 22.7 years. The men were taller and heavier than the female group but Body Mass Index means were again similar with the men at 25 and the women at 23.9. Out of a possible total score of 21, the mean Functional Movement Screening score was 15.8 for the men and 15.6 for the women. When looking at individual tests the females performed better on flexibility test with higher scores on the straight leg raise and the shoulder mobility tests. The men were seen to perform better on push-ups and rotary stability tests. Inter-tester reliability was found to be excellent on 6 of the tests and substantial on the rest.

As few articles have examined the Functional Movement Screen data, Schneiders et al (2011) provide a useful normative data set. However it must be acknowledged that they included people who participated in physical activity at any level. Therefore this data cannot be compared to specific sports or used to compare amateur or elite performance. The results were also recorded by only 2 Physiotherapists and no information was given regarding the qualifications and skill level however more research is needed on specific sports and performance levels.

2.7.3 Functional Movement Screen and Injury Prediction & Prevention

In 2009, Kiesel, Plisky and Butler investigated if an off season intervention programme could improve Functional Movement Screen scores. In their study, they collected data from 62 professional American football players from the same team. Each player was assessed and scored at the start of the study and then prescribed an individual 7 week training programme based on their personal FMS score. Injury risk threshold was defined as a score below 14 out of a possible 21 (Kiesel, Plisky, and Voight, 2007). Standard FMS tests and scoring systems were used (Cook et al 2006a; Cook et al 2006b; Cook, 2003).

At baseline measurement only 11% of players had a score above 14, the defined score for injury risk threshold. Post-intervention, this was improved to 63% above a score of 14. However it must be noted that 20 players still did not manage to achieve a score of 14 or above post-intervention. Another key finding of the study was that poor performance in the overhead squat seems to be the primary indicator for those who scored 14 or less. The study has shown that the motor control changes and deficits that may exist post injury were able to be identified by functional testing methods. Kiesel et al (2009) have only used one study to back up the injury threshold number of 14 (Kiesel et al, 2007). More studies are needed to explore the threshold that a score under 14 does increase injury risk. Overall the study has demonstrated that exercises, self-stretching and trigger point therapy designed specifically for an individual can improve functional movement screen scores. In future studies, a control group would help to improve the validity of the results to ensure a test learning effect is eliminated.

Chorba et al (2010) studied 38 female college athletes from a combination of football, volleyball and basketball to see if the Functional Movement Screen could predict injury in this target group. The participants were studied during the 2007-08 season and all injuries during this time were recorded. Again Chorba et al (2010) used Kiesel et al (2007) classification of 14 or less on the scoring system as the injury risk threshold. Baseline measures revealed that the mean score was 14.3. However it was noted that the mean score for those who had suffered an injury during the season (n=18) had a mean baseline score of 13.9. Football players sustained the highest number of injuries (n=8) and also had the lowest baseline mean score at 13.4. Although this study only looked at female participants, it did show a positive correlation between poor FMS scores and injury risk, especially in football. It is also important to recognise that 7 of the 38 athletes that participated in the study had previously undergone anterior cruciate ligament reconstruction. This particular group was seen to perform lower at baseline on the FMS and to be the most at risk for injury.

As the two previous articles reference the FMS injury threshold set out by Kiesel et al (2007), this article has also been reviewed. During one American football season, Kiesel et at (2007) recruited 46 players from one professional team to participate in the study. The athletes were screened on the FMS by an experienced tester at the beginning of the season and injuries occurring during the season were recorded by the same tester. Of a possible score of 21, the mean baseline FMS score was 16.9 for all players. The mean baseline score for players who sustained an injury in the season was 14.3 and the mean baseline score was 17.4 for those who did not sustain any injuries in the season.

From these results, Kiesel et al (2007) calculated the odds ratio of the likelihood of sustaining an injury and reported that those who scored 14 or less on the FMS score had an increase injury risk. Interestingly enough only 7 out of 46 players sustained a serious injury that required them to miss 3 or more weeks of training and matches. Therefore the figure that has been used in other studies as a threshold has been based on a sample size of only 46 American football players in which 7 sustained a serious injury, not a minor to moderate injury. As well as this, contact and non-contact injuries were included in data analysis. This could have affected the results due to the contact nature of American Football. From this data, it would seem logical to question if the score of 14 or less can actually predict any injury of any severity in any sport.

2.7.4 Reliability of the Functional Movement Screen

Minick, Kiesel, Burton, Taylor, Plisky and Butler (2010) considered the inter-rater reliability of the Functional Movement Screen by comparing individual testers with different levels of training. This particular study used 2 experts who were involved in developing the FMS tool compared to two novice testers. Minick et al (2010) defined an expert as having more than 10 years of experience with the tool and novices as having less than 1 year experience in using the FMS. Forty college students (23 women, 17 men) were studied, although only 39 participants were reported on due to the loss of 1 set of data. Each student was recorded by 2 cameras performing all 7 FMS tests (17 in total including individual right and left leg tests). Dartfish software was used to analyse the videos and the standard FMS 0-3 scoring system was used by testers. The weighted Kappa statistic was used to measure agreement between the 2 pairs of raters.

The 2 novice testers were found to have excellent agreement on 6 of 17 tests and substantial agreement on 8 tests. The experts demonstrated excellent agreement on 4 tests and substantial agreement on 9 tests. Lunge and rotary stability tests only showed moderate agreement in both expert and novice raters. When comparing novice to expert, 14 out of 17 tests showed excellent agreement. As a result of the findings in this study, Minick et al (2010) suggest some of the tests may require a 3D video approach instead of 2D. They also suggest test descriptions may need to be more clearly defined for midrange performance on the lunge, hurdle step and rotary stability tests.

One of the perceived benefits of the FMS is the ease of administration and low cost due to it not requiring expensive equipment (Chorba et al, 2010; Cook, 2003). This study used 2 cameras to record data and suggested that 3 cameras may be necessary for more accurate results. This potentially makes the FMS tool more expensive to administer and this equipment may not be available in less resourced environments. It is important to take into consideration that this study does not provide real-time data. It was never stated how long each rater had to review each recording and if the number of views were restricted. It is also pertinent to note that only 2 sets of raters (4 raters in total) were used and only 39 recordings were viewed. Despite this small sample size, this article is seen as a seminal piece of evidence for inter-rater reliability of the FMS.

Onate, Dewey, Kollock, Thomas, Van Lunen, DeMaio and Ringler (2012) decided to investigate real-time intersession and inter-rater reliability of the FMS as the majority of previous studies have looked at recorded FMS videos. Real-time analysis studies are important as they replicate the most common way in which evaluations will normally take place. In this study, 2 raters (one expert; one novice) scored 19 physically active subjects performing the FMS in real-time. The subjects were tested twice separated by one week. The standard FMS 0-3 scoring system was used (Cook et al 2006a; Cook et al 2006b; Cook, 2003).

Overall the study found good intersession and inter-rater reliability on 6 of the 7 tests. Hurdle step was the only test receiving a fair score. A key finding of this study was rater positioning. The raters were positioned slightly differently therefore a recommendation of anterior subject placement was reported to be the most advantageous. As the study only used 2 raters it acts as a good pilot study but needs to be carried out with more raters in the future.

The FMS has shown varying results with inter and intra-rater reliability (Onate et al, 2012; Minick et al, 2010). Only 1 study has been used to determine the FMS threshold level for injury prediction and this study has numerous limitations (Kiesel et al, 2007). Generally there is little data which shows the injuries that may be predicted by the FMS but one study did find poor performance on the deep squat appears to be the primary predictor of injury of the 7 FMS tests (Kiesel et al, 2009). Notably, there appears to be little to no correlation between the FMS and performance tests highlighting a need for a screening tool that is specific to the demands of the sport (Oxada et al, 2011; Parchmann and McBride, 2011).

2.8 Literature Review Conclusion

Overall it appears that functional movement screening is appropriate for football. However, there are no clear indications from the literature as to exactly which tests should be utilised in football. Although some tests from the FMS may replicate movements involved in football, justification for the inclusion needs to be provided. It also is essential to remember when developing a screening tool for football, only a small proportion of players are at elite level. Therefore it is advantageous and appropriate to develop simple tools requiring minimal resources that can be used across the different playing levels (Engebretsen et al 2008).

In light of the findings of this literature review, this study aims to specifically establish which tests should be included into a functional movement screening tool that is specific for football.

3.0 CHAPTER THREE METHODOLOGY *PHASE 1*

3.1 Justification of the modified two round Delphi Method

Delphi methodologies have been used in nursing and healthcare for decades (Powell, 2003; Rayens and Hahn, 2000; Duffield, 1993). The Delphi technique has been used to establish outcome definitions, treatment methods used in practice, clinical competencies required for specific disciplines and development of clinical questionnaires or clinical assessment tools (Antcliff et al, 2013; Donaldson and Finch, 2012; Griffith et al, 2007). Delphi methodologies have also been used in sport for identifying signs and symptoms of concussion, establishing best practice and developing clinical outcome measures (Haines, Baker and Donaldson, 2013; Sullivan et al, 2007; Weidner and Henning, 2004). The Chartered Society of Physiotherapy (CSP) also used a Delphi technique for identifying national research priorities in Physiotherapy and for developing evidence based practice guidelines (CSP, 2012; Rankin, Rushton, Oliver and Moore, 2012; Carnes et al, 2010)

There are a number of ways in which a Delphi technique can be used in the field. Traditionally the Delphi technique consisted of three rounds but over the years many researchers have reported using a two round modified technique (Sullivan et al, 2007; Mullen, 2003; Walker and Selfe, 1996). In a standard three round Delphi process, the first round usually involves gaining qualitative opinions and collecting information into subcategories from participants (Antcliff, Keeley, Cambell, Oldham and Woby, 2013; Custer, Scarcella and Stewart, 1999).The two round technique is often used to assist in continued participation between rounds and when it would be difficult to gain the necessary information from open ended questions in the first round (Mullen, 2003; Cantrill, Sibbald and Buetow, 1996). When reviewing the literature there is great variation in the Delphi methodology employed in each study. Mullen (2003) acknowledges these differences but emphasises the Delphi technique should be less prescriptive allowing it to be designed to fit the needs of the research project. Therefore taking a pragmatic view is important for accessing the right population, increasing response rates and ensuring continued participation (Mullen, 2003). Due to constraints and barriers in performing research in professional football, a modified Delphi technique was adopted for this study.

Although there is no current set level of agreement for a Delphi consensus panel, Walker and Selfe (1996) recommended a minimum of a 70% percentage agreement is used based upon a literature review of Delphi methodologies whereas McKenna's (1994) review suggests a percentage agreement amount of 51%. However some studies were even found to use 30% as acceptable agreement (Griffith et al, 2007). Mercer, Jackson and Moore (2007) specifically defined the bands of agreement with 0-50% agreement-no consensus, 50-74% agreement-majority view, 75-99% agreement-consensus and 100% agreement-unanimous. A narrowing process between rounds has been noted in some Delphi methodologies (Kingston et al, 2011; Griffith et al, 2007). This is often seen in studies that initially have a number of questions or themes identified in the first round. For example, Griffith et al (2007) used a Delphi consensus method to establish low-back pain definitions in occupational studies. As Griffith et al (2007) were asking the 6 experts to rate their level of agreement on 119 outcome definitions they employed a narrowing technique in which items were dropped in the second round if acceptable consensus had not been achieved. Other studies used a similar technique of employing a cut off threshold for inclusion into subsequent rounds but percentages for narrowing have not been reported (Kingston et al, 2011). As other studies have reported a minimum of 50% is needed to achieve agreement consensus (Griffith et al, 2007; Mercer et al, 2007), the 50% cut off point was used in the first questionnaire in this study. This process helped to reduce the number of unnecessary tests being brought forward to the second questionnaire which reduced test redundancy and the amount of time that it would take to complete the questionnaire.

In this study the panel of experts were asked to either select “yes or no” if they agreed with including a test into the Functional Movement Screening Tool for Football. The choice of “unsure/undecided” which has been seen in other Delphi methods was purposely left out as it was important for the panel of experts to make a decision on the inclusion of the test. An option that would allow participants to remain neutral was not desirable. The panel of experts were not asked to rank the order of importance with each test as the aim was solely to establish if the test should or shouldn’t be included in the screening tool and not to establish the level of importance of each test. Although many Delphi methodologies have used likert scales to assess agreement levels or a combination of “yes or no” answers with likert scales, this increases the amount of time it takes to complete the questionnaire. As the first questionnaire included 84 tests, using a likert scale would have increased the amount of time to complete the survey and potentially have affected response rates (Sahlqvist et al, 2011; Fan and Yan, 2010). Questionnaire response rates from Sports Physiotherapists only involving one round have been reported as low in previous research (Struyf, DeHertogh, Gulinck, and Nijs, 2012). As this study required participation in two rounds, a decision to use “yes or no” was adopted. This would still provide the necessary information on Physiotherapists who agreed or disagreed with the test being included in the Functional Movement Screening Tool for Football and supported continued, timely participation by the ease of the response method.

3.2 Application of the modified two round Delphi Method

Phase 1A of this project used a modified two round Delphi methodology. The Delphi method involves using a panel of experts to make independent decisions and private rating of agreement with a series of information (Kingston, Morgan, Jorm, Hall, Hart, Kelly and Lubman, 2011; Jones & Hunter, 2009). It is used to synthesize expert opinion in a systematic manner which features anonymity, controlled feedback & statistical aggregation of group responses (Griffith, Hogg-Johnson, Cole, Krause, Hayden, Burdorf, Leclerc, Coggon, Bongers, Walter and Shannon, 2007; Hasson, Keeney & McKenna, 2000; Walker and Selfe, 1996; McKenna, 1994). Specifically for this study it has been used to develop consensus of an expert panel's opinions collected in two rounds from an online questionnaire. The panel of experts in this study were Physiotherapists working in the English Premier League. The responses to each round are obtained anonymously and distributed back to the participants until consensus or agreement is established (Carnes, Mullinger and Underwood, 2010). This method helps to avoid a dominant opinion from a key individual's view obscuring the thoughts of other participants (Carnes et al, 2010; Walker and Selfe, 1996; Whitman, 1990). This is vital in developing a functional movement screening tool in football where certain football clubs' opinions could influence the decision making of other participants due to the hierarchy in football. This is also essential for this particular group as information sharing in professional football is normally kept to a minimum as clubs need to keep a competitive edge. In this study, a two round process was used where the researcher developed the list of subcategories and tests by conducting a literature review; this did not involve the participants (Custer et al, 1999; McKenna, 1994). This approach is referred to as a reactive or modified Delphi technique where a pre-generated list of items is prepared and used in Round 1 (Custer et al, 1999; Walker and Selfe, 1996; McKenna, 1994). A modified two round Delphi method is seen as advantageous in increasing response rates and reducing bias of group interaction and maintaining anonymity (Custer et al, 1999). Therefore the first round of this study gathered mostly quantitative information as the participants selected "yes or no" if a test should be included. Some qualitative information was obtained as participants were able to provide comments on any additional tests they felt should have been included. A stepped process was used with a consensus level of 50% being set for inclusion in Round 1 and a consensus level of 75% being set for inclusion in Round 2. The percentage of agreement for this study was based upon threshold criteria seen in other projects (Kingston et al, 2011; Griffith et al, 2007; Mercer et al, 2007; Quinn & Sullivan, 2000; Walker and Selfe, 1996; McKenna, 1994). A stepped process with an increasing level of agreement was used to narrow down the test selection in each round. An online questionnaire was chosen in order to reach the maximum number of participants as the English Premier League clubs are scattered across the country and to ensure the important factor of anonymity of the participants (Antcliff et al, 2013; You, Sadler, Majumdar, Burnett and Evans, 2012; Sahlqvist, Song, Bull, Adams, Preston, and Ogilvie, 2011).

3.3 Questionnaire Development

Functional movement screening has been developed in recent years to bridge the gap between isolated musculo-skeletal screening and tests that assess the dynamic demands of sport & physical activity. A single definition of functional movement screening in sport does not exist. However, Cook et al (2006b) who founded the widely used FMS tool suggests that it is the assessment of fundamental movement which captures the quality of the movement patterns related to a specific sport or activity in an attempt to pinpoint deficient areas of mobility and stability that may be over looked in the asymptomatic active population. Therefore a literature search was conducted to compile a pre-generated list of functional tests for the first online questionnaire. Literature sourced was from both Physiotherapy specific materials and football specific resources and incorporated journals and texts books. Upon searching the literature it became evident that screening in football was not purely limited to functional movement tests. Football requires balance, co-ordination, agility and aerobic and anaerobic fitness (Requena et al, 2009; Rosch et al, 2000). Physical fatigue, poor balance, co-ordination and proprioception have been identified as risk factors for injury (Frisch et al, 2011; Dvorak et al, 2000). Reiman & Manske (2009) point out that it is not easy to draw the line between physical and functional testing therefore agility and physiological fitness test have been included in the questionnaire to allow participants to decide which tests and tests categories should be included in a Functional Movement Screening Tool for Football. The categories listed on the questionnaire were as follows: functional tests, anthropometric tests, aerobic tests, anaerobic tests, agility test and muscle length tests. Only tests with performance instructions were included; this led to a total of 84 tests being included in the first online questionnaire. This included 42 functional tests, 7 anthropometric tests, 6 aerobic tests, 5 anaerobic tests, 11 agility test and 13 muscle length tests. Due to the large volume of tests included within the first questionnaire (84) descriptions have not been provided in the thesis but can be viewed in Appendix 1. Participants were able to view the definitions online by clicking on the test name thus ensuring standardised test instructions were available for all. For those tests included in the final Functional Movement Screening Tool for Football a full description is outlined within Chapter 8, thereby giving context and clarity in the discussion as to the relationship between the test and the risk of potential injury. This ensured standardised test instructions were available for all participants. The questionnaire was constructed using the SurveyMonkey online package. SurveyMonkey is a web based service used world-wide to collect data (Harland and Drew 2013). SurveyMonkey allows users to input their own questions and responses into a single database and produces an easy to use online survey (Harland and Drew, 2013).

3.4 The Questionnaire-Functional Movement Screening for Football

Functional Movement Screening for Football

1. Do you think the following test(s) should be included in a Functional Movement Screening Tool for Football? (Please remember to see document in the email for this survey which has descriptions of each test if you are unfamiliar with them)

	Yes	No
Deep Squat	☐	☐
Standing Long Jump	☐	☐
Functional Reach	☐	☐
Single-leg Squat	☐	☐
Triple Hop for Distance	☐	☐
Hexagon Test	☐	☐
In-line Lunge	☐	☐
Tandem Walking	☐	☐
Side Step Test	☐	☐
Trunk Stability Push Up	☐	☐
Star Excursion Balance Test	☐	☐
Tinetti Test	☐	☐
Multiple Single-leg Hop Stabilisation test	☐	☐
Rotational Stability (Prone Kneeling)	☐	☐
Up-Down Test	☐	☐
Vertical Jump Test	☐	☐
Carioca Drill/Test	☐	☐
Lateral Lunge Test	☐	☐
Double Leg Lowering	☐	☐
Timed Sit Up Test	☐	☐
Timed Press Up Test	☐	☐
Supine Bridge	☐	☐
Single-leg Supine Bridge	☐	☐
Shoulder Mobility Test	☐	☐
Step Down	☐	☐
Single-leg Cross Over Hop for Distance	☐	☐
Knee Bending in 30seconds	☐	☐
Static Balance-Stork Test	☐	☐
Hurdle Step	☐	☐

Active Knee Extension-90/90 Hamstring Test	☐	☐
Prone Bridge (Plank Test)	☐	☐
4 Square Step Test	☐	☐
Romberg Test	☐	☐
Side Hop Test(timed)	☐	☐
Endurance of Lateral Flexors (Side Plank)	☐	☐
One-Leg Cyclic Hop Test	☐	☐
Active Straight Leg Raise	☐	☐
Single-leg Hop for Distance	☐	☐
Figure 8 Hop Test	☐	☐
6m Timed Hop	☐	☐
Triple Jump for Distance	☐	☐
Medicine Ball Chest Pass	☐	☐
2. Do you think Agility testing should be included in a Functional Movement Screening Tool for Football?		
	Yes ☐	**No** ☐
3. Regardless of your answer to Question 2, if Agility tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
T-Test	☐	☐
505 Agility Test	☐	☐
5-10-5 (Pro Agility) Test	☐	☐
Edgren Side-Step Test	☐	☐
Slalom Test	☐	☐
Hurdle Test	☐	☐
Illinois Agility Test	☐	☐
Zig-Zag Run Test	☐	☐
Balsom Run	☐	☐
Arrowhead Agility	☐	☐
Compass Agility Drill	☐	☐
4. Do you think Anaerobic Fitness testing should be included in a Functional Movement Screening Tool for Football?		
	Yes ☐	**No** ☐

5. Regardless of your answer to Question 4, if Anaerobic Fitness tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
300 Shuttle Run	☐	☐
Running Based Anaerobic Sprint Test.	☐	☐
Squat Jump Test	☐	☐
Plyometric Leap Test	☐	☐
Sprint Fatigue Test	☐	☐
6. Do you think Aerobic Fitness testing should be included in a Functional Movement Screening Tool for Football?		
	Yes ☐	**No** ☐
7. Regardless of your answer to Question 6, if Aerobic Fitness tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Chester Step Test	☐	☐
20m Shuttle Run (Multi-stage Fitness Test	☐	☐
Yo-yo Intermittent Recovery Test	☐	☐
Yo-yo Intermittent Endurance Test	☐	☐
12 Minute Run	☐	☐
Loughborough Intermittent Shuttle Test	☐	☐
***8. Do you think Muscle Length testing should be included in a Functional Movement Screening Tool for Football?**		
	Yes ☐	**No** ☐
***9. Regardless of your answer to Question 8, if Muscle Length tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:**		
	Yes	**No**
Adductor/Groin Flexibility Test	☐	☐
Lumbar Erector Spinae Assessment	☐	☐
Quadratus Lumborum Assessment	☐	☐
Ober's Test (ITB)	☐	☐
Internal Rotators of the Hip Assessment	☐	☐
External Rotators of the Hip Assessment	☐	☐
Kendall's Test	☐	☐
Thomas Test	☐	☐
Modified Thomas Test	☐	☐

Piriformis Test	☐	☐
Gastrocnemius Test	☐	☐
Soleus Test	☐	☐
Sit & Reach Test	☐	☐
10. Do you think Anthropometric testing should be included in a Functional Movement Screening Tool for Football?		
	Yes ☐	**No** ☐
11. Regardless of your answer to Question 10, if Anthropometric tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Height	☐	☐
Weight	☐	☐
Body Mass Index	☐	☐
Body Fat-Skin Callipers	☐	☐
Thigh Girth	☐	☐
Calf Girth	☐	☐
Torso Height	☐	☐
12. Are there any tests which have not been included on this survey that you feel should be on a Functional Movement Screening Tool for Football? If yes, please list the names of the tests or descriptions of the tests in the box below.		
	Yes ☐	**No** ☐
Additional Tests:		

3.5 Survey Pre-Delphi Round 1

Prior to the start of the study, as seen in many studies the online survey was piloted and reviewed by 2 clinicians for ease of use and for establishing the time it would take to complete the study (Struyf et al, 2012; You et al, 2012; Fan and Yan, 2010). The clinicians both reported the questionnaire to be easy to understand and access. All online links worked and the online questionnaire ensured all items had been completed before the next section of the survey could be completed. This is important as Fan & Yan (2010) report technical failure of online questionnaire significantly decreases the response rate. At this time it was also established that it should take no longer than 30 minutes to complete the online questionnaire which is important as surveys over 30 minutes in duration have also been found to have decreased response rate (Fan and Yan, 2010; Randelli, Arrigoni, Cabitza, Ragone, and Cabitza, 2012).

3.6 Panel Formation

A Delphi consensus panel was used in *Phase 1* to decide which tests should be included into a Functional Movement Screening Tool for Football. For this particular study a two round technique was chosen. *Phase 1* commenced with the selection of a panel of clinical experts established which tests should be included in the functional movement screening tool. For this study, the panel consisted of Physiotherapists currently working with premiership football clubs in England. Chartered Physiotherapists only were used as according to the Football Association (FA) regulation 35.1.1 & 35.1.2, every club is required to employ a Senior Physiotherapist who is registered with the Health Professions Council (FA, 2013). In *Phase 1A,* Premiership Physiotherapists were targeted for the consensus panel of experts as these are the Physiotherapists working at the most elite level of football. Twenty email addresses of Physiotherapists currently working in the English Premier League (EPL) were obtained from the English Football Association. The 20 Physiotherapists were emailed regarding participation in the study (Appendix 2). They were sent an information sheet and a link for the online questionnaire (Appendix 3). Where possible the email was addressed directly to the club Physiotherapist if their name was known as personalised invites have been shown to increase response rate (You et al, 2012; Sahlqvist et al, 2011; Fan and Yan, 2010; Dillman, 2000). A reminder was also sent out one week prior to the close of the study again to maximise potential response rates (You et al, 2012; Sahlqvist et al, 2011; Fan and Yan, 2010; Kaplowitz, Hadlock, and Levine, 2004; Dillman, 2000).

Participants actively opted in to take part in this study. Due to a snowballing effect a further 6 email addresses were obtained from other Physiotherapists working in the EPL. Therefore a total of 26 Physiotherapists were contacted to participate in the study. In Round 1 the experts were asked to select the categories and a number of tests from each section which they believed should be included in a Functional Movement Screening Tool for Football. A final section of other was offered to all participants and in this section they could comment and add any further tests they felt would be appropriate for the inclusion into the screening tool.

From the responses from the online survey, categories and tests which received 50% or higher were included into a second online survey (Griffith et al, 2007; McKenna, 1994). Two additional tests were added to the functional heading in the second online survey as they were mentioned in the any other tests section of the survey. The new survey link (Appendix 4) was then emailed to the 26 Physiotherapists and only those who completed Round 1 of the survey were asked to complete the second online survey (Appendix 5). In this stage the panel once again selected tests from the newly distributed list which they felt should be included in the final tool for Functional Movement Screening in Football. As there is no current set level of agreement for a Delphi consensus panel, this study used 75% agreement mark based upon threshold criteria seen in other projects for inclusion into the final document (Kingston et al, 2011;

Griffith et al, 2007; Quinn & Sullivan, 2000). This round also collected demographic data on the participant set. Each participant was asked to select their current age bracket, number of years qualified and number of years worked in Premiership Football.

After completion of the two online survey rounds, participants were emailed regarding continued participation in *Phase 1B* of the study (Appendix 6). At this time, participants were advised that they would now be asked to discuss operational definitions and the scoring system for each of the tests to be included in the final screening tool. This phase consisted of using an online discussion board to allow interaction between participants. Each participant was given an anonymous user name to ensure their identity was not revealed to the other participants. Prior to being given access to the discussion board, each participant was required to complete an online consent form which outlined the details of the study and ensured the study information was not to be shared with anyone else (Appendix 7). Participants were asked to comment on provided definitions for each test and to re-comment on other participants views as the discussions developed.

3.7 Ethical Issues

Prior to the start of the study, ethical approval was gained from the Built, Sport and Health (BuSH) Ethics Committee, University of Central Lancashire (Appendix 8). Ensuring and maintaining confidentiality and anonymity were imperative in this study. Information sharing in professional football is not common practice as clubs are competing against each other and strive to be ahead of the competition. To ensure anonymity an online survey approach was employed (Antcliff et al, 2013; You et al, 2012; Sahlqvist et al, 2011).The survey did not record the participants' personal details and all responses were automatically anonymised in *Phase 1A*. Each participant received an information sheet with details of the research process before opting to participate. In *Phase 1A* they were emailed an information sheet and a link to the online survey and had up to 4 weeks to decide whether to take part in the study so that any concerns they may have had could be addressed (Appendix 2). Participants had to actively opt in to take part in this phase of the study. The participants in *Phase 1B* were given 7 days to consider continued participation in the study and were asked to complete and return a consent and confidentiality form should they wish to continue to take part in the study (Appendix 7). All participants were given the opportunity to withdraw from the study at any time. Personal records of participants in *Phase 1B* have been kept in a locked filing cabinet or on personal computer files that are password protected. Data has been stored at UCLAN in line with University policy. Only the researcher and the supervisory team of the project have access to personal data/information.

3.8 Data Storage

All data has been stored in accordance with UCLan regulations. All electronic data has been stored on password-protected computers. All consent forms and other data, which have been collected, were given anonymity by coding any participant names; and stored in a lockable filing cabinet within a locked room with restricted access. Data will be kept for 5 years following the study, and then destroyed.

3.9 Analysis

Percentage agreement was used to establish the level of consensus in each round (Kingston et al, 2011; Griffith et al, 2007; Quinn & Sullivan, 2000; Walker and Selfe, 1996). Descriptive statistics were used to describe the participant set and data collected from the online questionnaire survey. These have been displayed in tables, graphs and text to illustrate the results. Responses from open questions were included into the second round of the online survey in the appropriate test category.

4.0 CHAPTER FOUR RESULTS *PHASE 1A*

4.1 Questionnaire Results Online Delphi Round 1

A total of 14 Physiotherapists out of a sample of 26 completed the online questionnaire for Round 1. Full results are available in Appendix 9. From the responses from the online questionnaire, categories and tests which received 50% or higher were included into a second online survey (McKenna, 1994; Griffith et al, 2007). At this stage 4 categories (Table 4) and 32 tests (Table 5) were selected by 50% or more of the participants. The categories of aerobic (28.57%) and anaerobic (42.86%) tests received less than 50% selection; therefore tests in these categories were not included into Round 2.

Table 4-Categories Selected for Inclusion into Online Questionnaire Round 2

Categories Receiving 50% Selection or Higher in Round 1	Categories Eliminated in Round 1
Functional Tests Agility Tests Muscle Length Tests Anthropometric Tests	Aerobic Tests Anaerobic Tests

Of the 32 tests selected by 50% or more of the participants, 17 were functional tests, 2 were agility tests, 7 muscle length tests and 6 anthropometric tests. Two additional tests (Y-balance test and standing lunge test) were added to the functional category in the second online questionnaire as they were recommended in the “any other tests” section of the survey. A total of 53 tests were eliminated in Round 1 as they did not receive selection from at least 50% of the participants. In total 23 functional tests, 9 agility tests, 6 muscle length tests, 1 anthropometric test, 5 anaerobic tests and 6 aerobic tests were ruled out in *Phase 1A,* Round 1.

Table 5-Tests that received 50% or higher selection from participants in Round 1

Test Receiving 50% Selection or Higher in Round 1	
Functional Tests	Agility Tests
Deep Squat	T-Test
Single-leg Squat	Slalom Test
In-line Lunge	
Vertical Jump	Muscle Length Tests
Single Leg Supine Bridge	Piriformis Test
Hurdle step	Gastrocnemius Test
Lateral Lunge Test	Soleus Test
Supine Bridge	Internal Rotators of the Hip
Step Down	External Rotators of the Hip
Endurance of Lateral Flexors (Side Plank)	Adductor Flexibility
Active Straight Leg Raise	Modified Thomas Test
Single-leg hop for distance	
Star Excursion Balance Test	Anthropometric Tests
Trunk Stability Push-up	Calf Girth
Multiple Single-leg hop stabilisation test	Thigh Girth
Rotational Stability (Prone Kneeling)	Height
Triple Hop for Distance	Weight
Y-balance Test	BMI
	Body Fat Skin Calipers

4.2 Questionnaire Results Online Delphi Round 2

Eight Premiership Football Physiotherapists completed the second online questionnaire and full results are available in Appendix 10. Demographic data revealed all participants were between the ages of 30-49 years. All participants had been qualified for a minimum of 6 years with one participant reporting to be qualified in the 16-20 year bracket. All participants had been working in Premiership football for at least one year with the highest number of years being reported in the 26-30 year bracket by one participant. Results of the second survey found that 2 categories encompassing 12 tests received over 75% agreement; these were therefore included in the final test document (Kingston et al, 2011; Griffith et al, 2007; Quinn & Sullivan, 2000). Agility testing was only selected by 37.5% of the participants and anthropometric tests by 62.5% of the participants; therefore they were eliminated from the final protocol as they did not reach the 75% threshold (Table 6).

Table 6-Headings Selected for Inclusion into Online Questionnaire Round 2

Headings Receiving 75% Selection or Higher in Round 2	Headings Eliminated in Round 2
Functional Tests Muscle Length Tests	Agility Tests Anthropometric Tests

Table 7 shows the 12 tests that were selected by 75% of the participants and therefore included into the final screening document. Of the functional tests, interestingly only the in-line lunge test was selected by 100% of the participants. The Y-balance test was only just included as it was selected by 75% of the participants. Single-leg squat, vertical jump and deep squat were selected by 87.5% of all participants. In the muscle length category only the modified Thomas test was included by 100% of the participants. Adductor/Groin flexibility tests and the internal and external rotators of the hip assessments were selected by 87.5% of participants and the gastrocnemius and soleus tests by 75% of participants. Thirteen functional tests were eliminated in Round 2 and as the category of agility and anthropometric testing were eliminated a further 8 tests were also eliminated from these 2 categories. In total 23 tests were eliminated in Round 2. The hurdle-step functional test was eliminated in Round 2 as it was only selected by 50% of participants. This was an interesting result as in Round 1 it had been selected by 78.5% of the participants.

Table 7-Tests that received 75% or higher selection from participants in Round 2

Test Receiving 75% Selection or Higher in Round 2	
Functional Tests	**Muscle Length Tests**
Deep Squat	Piriformis Test
Single-leg Squat	Gastrocnemius Test
In-line Lunge	Soleus Test
Vertical Jump	Internal Rotators of the Hip
Y-balance Test	External Rotators of the Hip
	Adductor Flexibility
	Modified Thomas Test

5.0 CHAPTER FIVE DEVELOPMENT OF *PHASE 2*

5.1 Discussion of Results *Phase 1A*

5.1.1 Response Rates-*Phase 1A*

Of the 26 Physiotherapists initially contacted, 14 (54%) participated in the Round 1 of the study. This percentage is higher than found generally with recent online questionnaire surveys (Chau, Chadbourn, Hamel, Mok, Robles, Chan, Cott and Yeung, 2012; Struyf et al, 2012). Most web based surveys report anywhere between 3-40% response rate, with Physiotherapy specific online questionnaires reporting response rates between 3-29.2% (Chau et al, 2012; Randelli et al, 2012; Struyf et al, 2012; You et al, 2012; Sahlqvist et al, 2011). In this study, a response rate of 54% was higher than expected as this specific group of participants is often difficult to access and due to issues associated with competitive advantage information is not regularly shared in elite professional sport. Struyf et al (2012) reported only a 3% response rate from Physiotherapists and found Sports Physiotherapists in particular were the group that responded the least. In Round 2 of the survey, 8 Physiotherapists continued with the second online survey. This made up 31% of the original population contacted and is still at the high end of the expected response rate for questionnaire surveys (Chau et al, 2012; Randelli, et al, 2012; Struyf et al, 2012; You et al, 2012; Sahlqvist et al, 2011). As all information was collected anonymously, it proved difficult to ensure the same participants that completed Round 1 of the survey also completed Round 2 of the survey. A generic email reminder was sent to all participants for both surveys one week prior to the deadline to encourage further participation (You et al, 2012; Sahlqvist et al, 2011; Fan and Yan, 2010; Kaplowitz et al, 2004; Dillman, 2000).

5.1.2 Further Test Inclusion

At the end of Round 1, participants had the option to comment on any further tests they felt should be included in the survey. Nine participants commented on this section with 2 specific tests being recommended for inclusion. The 2 further tests suggested were the Y-balance test and the dorsiflexion lunge test. Both of the tests were put forward by more than one participant and were included in the questionnaire in Round 2. Despite being added on participant request, the dorsiflexion lunge test was not selected for final inclusion in the screening tool. However the Y-balance test was selected over the star excursion balance test and was included in the final tool as it was selected by 87.5% of participants. The Y-balance test is new to the therapy world and very little research has been conducted on the test. It has been developed as an addition to the FMS and requires the specific testing apparatus which limits its accessibility.

5.1.3 Functional Testing

A total of 42 functional tests were included in Round 1 of the survey. Only 17 functional tests were selected to progress into Round 2 and of these 17 tests, 5 were included in the final screening tool for football. This meant the 7 other tests included in the final screening tool did not come from the functional tests category. Of the 7 FMS tests designed by Cook et al (2006) only 2 tests were selected to be included in the final screening tool for football; the in-line lunge and deep squat. The shoulder mobility test was eliminated in Round 1 and the trunk stability push up, rotary stability, active straight leg raise and hurdle step in Round 2.These findings may back up the theory that screening should be specific to the sport and not a generic "one tool fits all" philosophy (Schneiders et al, 2011; Requena et al, 2009). However, these results contradict some of the tests currently used in football screening tools. Frohm et al (2011) who specifically targeted football included the push up, shoulder mobility and active straight leg raise tests. Rosch et al (2000) also included the active straight leg raise in the F-MARC football testing battery. The triple jump test is also used in the F-MARC football test battery. Even though the triple jump test has been shown to predict lower limb strength, power and detect muscle imbalance (Hamilton, Shultz, Schmitz and Perrin, 2008) it was eliminated in Round 2 of this study.

Amongst the functional tests, a number of core stability and abdominal control tests were included on the first survey but none were selected for the final screening tool. Of these tests, the double leg lowering and plank tests were eliminated in Round 1. The side plank, supine bridge and single leg supine bridge were eliminated in Round 2. Although these tests may not be traditional functional measures, the core has been shown to be important in functional movements and sports performance (Okada et al, 2011). The supine bridge and particularly the single leg supine bridge not only assess core function but also evaluate gluteal and hamstring function which is vital in football (Lees and Nolan, 1998). However, they were not included in the functional screening tool for football as selected by this consensus panel.

5.1.4 Aerobic and Anaerobic Testing

The results from Round 1 revealed 2 test categories were eliminated. Interestingly, the 2 categories eliminated in Round 1 were aerobic and anaerobic tests. Football is described as a sport which requires the use of both the aerobic and anaerobic energy systems (Requena et al, 2009; Arnson et al, 2004). Therefore, it calls into question if they should be included in a functional movement screening tool. As there is no set definition of what is meant by functional movement, this panel of experts have deemed aerobic and anaerobic testing not to be included in the functional screening tool for football. However, both Requena et al (2009) and Rosch et al (2000) who specifically screened in football, included sprint based anaerobic tests. In addition to this, Rosch et al (2000) also screened aerobic performance in their F-MARC test battery. Frisch, Urhausen, Seil, Croisier, Windal and Theisen (2011) who studied the association between functional tests and injuries in football also included aerobic & anaerobic tests in their study as functional markers. Frisch et al (2011) found physical fatigue was significantly related to injury as predicted by an aerobic based multi-shuttle test. Therefore, the results of this study do not match trends seen in items included in other football screening tools which may be due to the participants in the study being Physiotherapists.

5.1.5 Agility Testing

In Round 1, 64% of the participants selected to include agility testing in the screening tool; however in Round 2 it was only selected by 37.5% of participants and was therefore ruled out. Of the 11 agility tests, only 2 tests were selected to progress to Round 2; t-test and slalom test. The 5-10-5 pro agility tests was only selected by 14.3% of participants in Round 1, the Balsom run by 28.6% and the zig-zag run test by 42.9% of participants. This was interesting as these 3 tests have been recommended for use in football (Walker & Turner, 2009) but they were rejected by the majority of the panel. Although the 2 tests selected for progression into Round 2 may be used in football, neither were developed specifically for football. The slalom test and the t-test are used for any multi-directional sport (Reiman and Manske, 2009). This raises the question as to whether or not the panel has kept up to date with evidence based practice or if they simply use tests already in place or tests they learnt during their training.

5.1.6 Anthropometric Testing

After Round 1 the category of anthropometric testing was included in Round 2 of the survey with 6 of the 7 tests also being included in the second round. Anthropometric tests are often described as measurements of the dimensions of the human body (Reiman & Manske, 2009). Some studies have found links to certain anthropometric characteristics in relation to potential injury risk factors (Arnason et al, 2004). However, as they are not normally considered functional tests, it was surprising that the category made it through the first round. Of particular interest both in Round 1 and Round 2 of the survey, Body Mass Index (BMI) was selected by 62.5% of participants for inclusion in the final screening tool. Specifically in sport, BMI has been heavily criticised for not being a true measure of body fat (Engebretsen et al 2010c; Gabbe et al, 2004). Although it was not included in the tool it was unexpected to receive so many votes as it is known to have questionable validity in sport due to athletes having a high percentage of muscle mass (Gabbe et al, 2004). The anthropometric category only received 62.5% selection in Round 2 and therefore was eliminated. If the category would have been selected for inclusion, height, weight and body fat skin callipers all received over 75% selection and would have been included in the screening tool.

5.1.7 Muscle Length Testing

Surprisingly the muscle length testing category was selected to be included in the final Functional Movement Screening Tool for Football. Although reduced muscle length may be a risk factor for injury (Witvrouw et al, 2003) it is not normally considered a functional test as most muscle length measures are taken in an isolated, non-functional position. In Round 1 of this study, 78.5% felt the muscle length tests should be included in the functional screening tool and 75% selected it again in Round 2 leading to its inclusion in the final screening tool for football. Of the 13 tests listed in this category, 7 were included in the final screening tool. Lumbar erector spinae assessment, quadratus lumborum assessment, Ober's test, Kendall's test, Thomas test and the sit and reach test were all eliminated in Round 1 of the survey. The remaining seven were all selected in Round 2 by 75% of participants or higher and were therefore included in the final functional screening tool for football.

Again this panel has to some extent decided against tests currently used in football screening. Although the protocol was slightly different, Rosch et al (2000) included a test which incorporated a measure of erector spinae muscle length in the F-Marc football test battery. The exclusion of the sit and reach test is discussed below.

5.1.8 Hamstring Testing

Muscle strains are commonly reported in football (Ekstrand et al, 2011; Ekstrand et al, 2009; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). In particular of these strains, hamstring injuries have been found to account for 12-37% of muscle strains (Ekstrand et al, 2011; Ekstrand et al, 2009; Hawkins et al, 2001). The online survey included three tests that have been used in other studies to measure hamstring length and as a potential injury risk predictor. These tests were the active straight leg raise, 90/90 active knee extension and the sit and reach test; however none of these tests were included in the final functional screening tool. This unexpected result may be due to a few reasons. It is not as surprising that the sit and reach test was rejected at Round 1. Although previously this test was used regularly in sport, many authors have now reported the test not to be hamstring specific as lumbar and neural flexibility are also placed on stretch (Gore, 2000). Hoare (1997) reported athletes with normal sit and reach scores displayed hamstring tightness with the 90/90 active knee extension test. Therefore it is not frequently used to specifically measure hamstring length in contemporary sporting environments.

The sit and reach test was the only hamstring length test listed in the muscle length category. Both the active straight leg raise test and the 90/90 active knee extension test were placed in the functional test category. This may be a further reason why they were not included. When reviewing the literature the active straight leg raise as described by Cook et al (2003) is a part of the 7 FMS tests. As the Cook et al (2003) screening tool is based around functional tests, the decision was made to assign the test to the functional category. The active straight leg raise did make it into Round 2. However in this round it was selected by less than half of the participants and therefore it was not included in the final screening tool for football. Again it must be noted that the active straight leg raise is not purely focussed on hamstring length as the neural system may also be stressed in this test (Gore, 2000; Gajdosik and Lusin, 1983). This is not undesirable as Engebretsen et al (2010c) have reported a number of hamstring strains to incorporate a neural component as well, but the panel of experts did not consider the test as appropriate for inclusion in the final screening tool for football.

Of the 3 tests rejected, the 90/90 active knee extension test is the most surprising. Literature has reported the 90/90 active knee extension test to be a reliable measure of true hamstring length and a predictor of hamstring injury (Reiman and Manske, 2009; Gajdosik and Lusin, 1983). Therefore it is baffling as to why the experts discredited the test in Round 1, especially when it is common knowledge that hamstring injuries account for a large proportion of injuries in football (Ekstrand et al, 2011; Ekstrand et al, 2009; Hawkins et al, 2001). There are two proposed reasons for the exclusion of this test. As with the active straight leg raise, the 90/90 active knee extension test was included in the functional tests section. Results of the questionnaire survey revealed 7 tests from the muscle length category were included in the final functional screening tool. Therefore it is speculated that the 90/90 active knee extension test may have been included if it had been placed in the muscle length category instead of the functional tests section. The second factor is that the Physiotherapists may have been unfamiliar with the test. If a Physiotherapist has not keep up with evidence based practice and efficiency of assessment methods, this test may not have been recognised for the potential it has shown in the literature (Reiman and Manske, 2009; Gajdosik and Lusin, 1983).

5.1.9 Individual Breakdown of Results Round 2

There was no one under the age of 30 or over the age of 50 that participated in *Phase 1A* of this study with the modal age bracket being 35-39 years of age**.** Years qualified ranged from the 6-10 year bracket to 26-30 years qualified with 16-20 years being the most reported bracket. All participants had been working in football for a minimum of 1 year and no one reported more than 25 years experience. All participants were currently working in the English Premier League at the time of completing the questionnaire survey.

Of the 8 participants who completed Round 2, only 2 participants selected all of the 12 tests that were included in the final functional screening tool for football. At the other end of the spectrum, one participant only selected 7 of the tests included. The majority of the panel had selected 10 or 11 of the tests included in the final screening tool. The in-line lunge and Thomas test were the only tests selected by 100% of the participants.

5.2 Limitations of *Phase 1A*

There are a number of limitations to *Phase 1* of this study. As this group of experts are known to be difficult to access and it is not desirable to share information with the competition, methodological decisions had to be made with reference to maintaining anonymity and maximising response rates. Participants were not required to contact the researcher to express interest in the study; the survey link was included in the initial contact email and participants only needed to make direct contact with the researcher if they had any questions, comments or concerns. Consent was gained by participants actively opting to take part in the study. In terms of response rates for Round 1, this methodological approach appeared to work as 54% of those contacted took part in the first round. This was higher than reported in other studies (Chau et al, 2012; Randelli et al, 2012; Struyf et al, 2012; You et al, 2012; Sahlqvist et al, 2011). However, this posed a slight problem for Round 2 of the Delphi process. Usually only those who participate in the Round 1 Delphi process would continue with the study. Due to the approach taken, there was no way of knowing exactly which of the 14 Physiotherapists were that took part in Round 1. This meant the email and link for the second survey had to be sent out to all 26 Physiotherapists contacted in Round 1. The email did clearly ask that only those who participated in Round 1 should complete the second online survey but there was no way of ensuring this process (Appendix 5). This was highlighted with two of the tests in the survey. In Round 1, both the hurdle step and single leg supine bridge were selected by over 75% of the participants. However, in Round 2 both were only selected by 50% of participants meaning participants changed their mind as a time lag between rounds allowed for reflection. It is also possible different participants were involved in the second round. This might also have also contributed to 6 Physiotherapists not continuing with the study as there was no way to target them and send specific reminders. However, despite this potential flaw, 8 Physiotherapists (31%) completed the second online survey and this is still higher than reported in other studies (Chau et al, 2012; Randelli et al, 2012; Struyf et al, 2012; You et al, 2012; Sahlqvist et al, 2011). Demographic data was also only collected on the second survey as it was anticipated that participants would continue with both rounds of the survey. Therefore demographic data was not available for the 6 participants that only completed Round 1.

In order to have facilitated continued participation on the consensus panel, it would have been beneficial to have contact information for the panel members. In order to maintain anonymity from the researcher collecting data an independent researcher could have been used to as a central point of contact for participants to confirm interest and to distribute the questionnaires to those who decided to participate (Thomas et al, 2011). This would have ensured only those who participated in Round 1 received the online survey for Round 2. This is desirable as it was possible different participants completed the survey in Round 2 meaning consensus from the same participants was not definitely gained.

Test sequence and ordering on the online survey may also be a crucial limitation to *Phase 1A* of this study. No hamstring muscle length tests were included in the final screening tool for football. Although the survey was carefully designed, some tests could have been included in more than one category; therefore a decision of best fit had to be made. As a number of muscle length tests were included in the final screening tool, placing the 90/90 active knee extension test in the functional category may have disadvantaged this test selection. However in other studies, hamstring length tests have been considered functional tests and it may be that this panel of experts did not feel the test was relevant for this specific tool.

On further review of the literature, one testing category may have been left out completely as some screening tools have included sport specific skills. Although some of the tests included in the questionnaire may replicate football specific movements, actual football specific skills such as dribbling and kicking were not included on the questionnaire. Football skills are not generally considered functional movement tests, but as there is no clear definition of what constitutes a functional movement, it might have been an idea to include a football skills category with specific football skills tests in the questionnaire allowing the panel to decide if these tests should be included in the final screening tool for football. However none of the participants suggested adding football specific skills in the screening tool when they had the opportunity to comment on addition of any other tests.

After reviewing the tests selected by the consensus panel for inclusion in the final screening tool, the issue of a lack of understanding of functional screening was again highlighted. Functional screening may be carried out for more than one reason. Generally Physiotherapists carry out functional screening to identify athletes that may be at risk for injury (Mottram and Comerford, 2007; Blanch, 2005; Bahr and Holme, 2003). Functional screening was developed in order to replicate movements directly linked to the requirements of the sporting function (Schneiders et al, 2011; Requena et al, 2009; Rosch et al 2000). It aimed to move away from isolated, plinth based tests. However, 7 isolated muscle length tests were selected for the final screening tool in football. In a number of studies there also seems to be conflicting information with performance indicators also being classified as functional tests, i.e. agility, aerobic and anaerobic tests (Schneiders et al, 2011; Requena et al, 2009; Rosch et al 2000). Although some data does exist linking injury risk factors and performance indicators, it is not substantial or conclusive. At the start of the study, it might have been beneficial to define functional movement screening or have a section on the survey allowing the panel to discuss and establish their own working definition of what constitutes functional movement screening in football.

Finally, an online questionnaire survey was used in this study to maintain anonymity and to reach a wider audience. However, questionnaires also have their limitations. In this study, participants simply selected yes or no to including a specific test. No dialogue was developed around the decision of including a test as would normally be seen with focus groups or interviews. Participants also selected tests from a pre-formed list. They did not start from a blank canvas and imagine which tests they would include if they were designing the tool themselves from scratch. Participants were given the opportunity at the end of the survey to add additional tests but other studies have found that towards the end of a survey responses get quicker and shorter and full views may not be expressed (Fan and Yan, 2010; Randelli et al, 2012). However, the online survey accomplished its objectives by achieving a 54% and 31% response rate and establishing consensus on 12 tests to be included in a Functional Movement Screening Tool for Football.

5.3 Evolution of *Phase 2*

After completion of *Phase 1A*, the next part of the study, *Phase 1B* aimed to establish operational definitions for each test selected to be included in the Functional Movement Screening Tool for Football. In *Phase 1B*, any participant who had completed *Phase 1A* was invited to continue with the study. This resulted in the recruitment of 3 Physiotherapists to take part in *Phase 1B*. Participants in this phase were given username and passwords to an online discussion board where they were asked to comment on test definitions/protocols for each of the 12 tests selected for the screening tool. Participants were called by participant numbers in order to protect anonymity. Each participant signed a consent form and agreed to keep information shared confidential (Appendix 7).

To initiate discussions, the test protocol that was available when completing the online survey was placed in the comment box on the discussion board for each individual test. This definition was the reported protocol from the source of the test. Participants were asked to comment if they agreed with the protocol or if they felt it needed changing or updating. Participants were also asked to consider how good or poor performance or execution of the test would be measured for each individual test. Suggested performance measures were given from the source for some of the tests but this was not available for every test. Dialogue from the online discussion can be found in Appendix 11.

Establishing operational definitions for each of the tests proved to be quite challenging for the participants. The participants could not agree on operational definitions for the gastrocnemius and soleus muscle length tests. The test protocols stated in the online survey measured gastrocnemius and soleus muscle length in a non-weight bearing position. Comments from the participants suggested that these tests should be done in a weight bearing position as it is more functional for football. However in *Phase 1A* weight bearing versions of these tests were offered but they were rejected by the panel, therefore the participants in *Phase 1B* were going against the consensus. When it came to discussing the piriformis length test protocol, two participants began to question its relevance in football and suggested maybe it shouldn't have been included in the tool even though they selected it. Again, discussions around the Thomas test revealed participants had concerns over the test's reliability and issues with standardising the protocol. It was becoming evident that the group was questioning some of the tests they had chosen to include in the functional screening tool.

Discussions on the functional test protocols highlighted further concerns. As previously stated by Engebretsen et al (2008) functional screening should be inexpensive and available to those working in any level of the sport. The group was not willing to consider an alternative protocol for the Y-balance test that did not require purchasing the Y-balance test kit. Additionally the protocol that was developing for the vertical jump height measurement was using a jump mat. As well as this, in the muscle length section, the use of an electronic goniometer had been mentioned on a number of occasions. The Functional Movement Screening Tool for Football was beginning to look expensive and the group was also questioning the inclusion of some of the tests that had been selected to be included in the final tool.

It was identified that some of the tests selected in the final screening tool did not follow suit with tests included in other functional screening tools. Some of the tests excluded had actually been shown to be favourable in current literature as screening measures. In light of the unexpected results in *Phase 1A* and the difficulties encountered in *Phase 1B*, it was decided that the functional screening tool developed in *Phase 1A* might not be the most representative for the use in football and in particular for use across any level of play. Therefore *Phase 2* of the project evolved into evaluating the level of agreement of each test included in the final screening tool by a different group of Physiotherapists working at different levels of football in England.

6.0 CHAPTER SIX RE-EVALUATION OF THE FUNCTIONAL SCREENING TOOL FOR THE USE IN FOOTBALL

6.1 Methodology *Phase 2*

A total of 26 Physiotherapists working in non-Premiership football were recruited to review and evaluate the tests chosen by the consensus panel in *Phase 1*. This population was chosen as the tool developed is not designed to target a specific ability level; it has been designed for use in football at any level. The researcher distributed the Functional Movement Screening Tool for Football that was developed in *Phase 1* to the recruited group in order to gain their agreement levels on the individual tests included in the tool developed by the consensus panel. Each participant was asked to rate each individual test on the functional movement screening tool developed in relation to their agreement for the tests to be used in football. This ensured different groups of Physiotherapists have been able to comment on the newly developed screening tool.

A total of 140 clubs from the Championship, League 1, League 2, the Football Conference Premiership, the Football Conference North and the Football Conference South were contacted regarding participation in this study (Figure 1). Contact information for the Physiotherapists was gained from club websites.

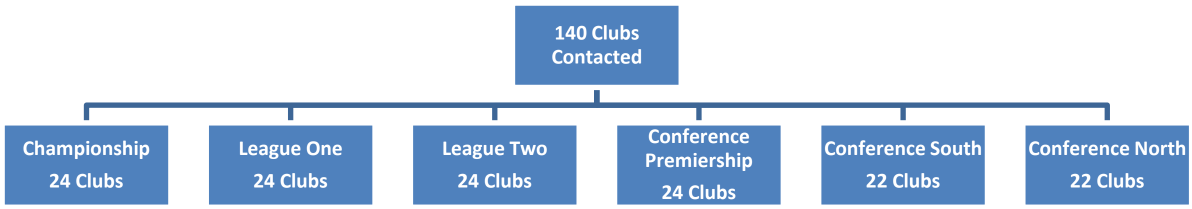

Figure 1 Football Clubs Contacted for Participation in the Study

Of the 140 club websites accessed, only 19 clubs listed the name of the Club Physiotherapist and of the 19 listed, only 7 websites listed direct contact email addresses for the Physiotherapist. The recruited sample were sent a link to an online questionnaire survey that allowed them to review each test selected for the screening tool and allowed them to rate each individual test. The online data was collected anonymously. As only 7 direct email addresses were available, the remaining 133 clubs were contacted via either the club secretary or general enquiries email address. The email asked the recipient to please forward the invite onto to the Club Physiotherapist. Two weeks after sending out 140 email invites, only 2 Physiotherapists had completed the online questionnaire. At this time, a reminder email was again sent out to the clubs. At this stage, it was also decided to take a more traditional approach and send out postal invites to the online survey in case the email invites were not being passed on to the Club Physiotherapists. The postal addresses for the 140 clubs were obtained from club websites and the postal invite and information sheet was addressed for the attention of the Club Physiotherapist. After sending out the postal invites, 8 Physiotherapists completed the online questionnaire bringing the total to 10 completions. As less than 10% of the population had responded, finally twitter was also used to recruit potential participants.

Twitter is an online social network platform. It is accessed by millions of people every day and has a network of over 500 million members (Twitter, 2014). A twitter account was created using the screen name of soccer research. A member search was performed using the words Physiotherapist and Football. A total of 30 members were found matching this criteria and the researcher began to follow these members. As twitter only allows a post of 140 characters, a precise message was devised and a shortened URL was created to link users to the study details. After careful consideration the following message was posted on the researchers twitter page *"UK Football Physios interested in functional screening? Please RT (retweet) or complete to* *assist with my doctoral study bit.ly/1dLQgSs."* The online address directed the reader to the study information page and the link to the online survey should the reader chose to participate. A summary of the study was stated on the webpage and a link to the full study information sheet was made available for viewing. Inclusion and exclusion criteria were placed on the webpage as well. Initially five Physiotherapists within the identified twitter network were targeted to share the study information. This led to further re-tweets from users who follow these members. Over a three week period, the above message was posted 10 times on the researcher's page and a total of 43 retweets took place in this time frame. After sharing the information on twitter a further 16 Physiotherapists completed the online survey, therefore a total of 26 Physiotherapists participated in *Phase 2 of* this study (Figure 2).

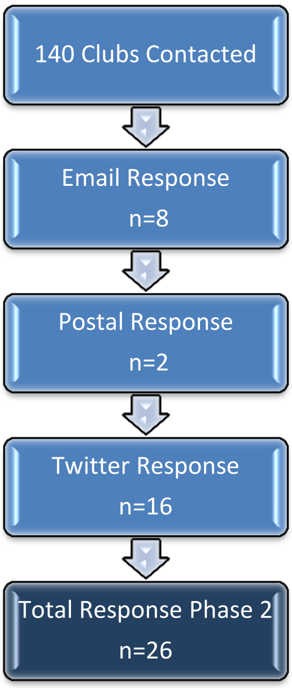

Figure 2 Recruitment of Participants in *Phase 2*

6.2 Questionnaire Development

The online questionnaire was developed by reviewing methodologies of similar studies (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al, 2012; You et al, 2012). A likert scale was used as the aim of the online questionnaire was to establish the agreement levels on the tests included into the Functional Movement Screening Tool for Football developed by a panel of clinical experts in *Phase 1* of the study. For this project study a 5-point likert scale was used allowing participants to indicate the strength of either agreement or disagreement for a specific test included in the Functional Movement Screening Tool for Football (Antcliff et al, 2013; Thomas, Nelson, and Silverman, 2011). In a likert scale, the intervals between choices are considered to be equal (Thomas et al, 2011). The five choices in this survey were; strongly agree, agree, neither agree or disagree, disagree or strongly disagree (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al, 2012; You et al, 2012; Thomas et al, 2011). These are standard responses used in a 5-point likert scale (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al, 2012; You et al, 2012; Thomas et al, 2011). A 4-point likert scale was considered where participants are forced to make a decision and stops participants from remaining neutral, but most similar studies used a likert scale with a neutral choice and therefore this study opted to match their methodology (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al,2012; You et al, 2012).

6.3 The Questionnaire

Functional Movement Screening in Football				
1. Do you think the Deep Squat test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
2. Do you think the Single-leg Squat test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
3. Do you think the In-line Lunge test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
4. Do you think the Y-balance Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
5. Do you think the Vertical Jump Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
6. Do you think the Adductor/Groin Flexibility Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
7. Do you think the Internal Rotators of the Hip Assessment should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐
8. Do you think the External Rotators of the Hip Assessment should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)				
Strongly Agree ☐	Agree ☐	Neither Agree or Disagree ☐	Disagree ☐	Strongly Disagree ☐

9. Do you think the Modified Thomas Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

10. Do you think the Piriformis Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

11. Do you think the Gastrocnemius Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

12. Do you think the Soleus Test should be included in a Functional Movement Screening Tool for Football? (Please remember to click on the test name for a description if you are unfamiliar with the test)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Demographic Data.

Below you will find four demographic questions. The responses from this section will be used to describe the participant data set who took part in this study.

1. Please tick the box that best indicates the level of football you are currently working in.

- ☐ Championship
- ☐ League One
- ☐ League Two
- ☐ Football Conference
- ☐ Other

2. Please tick the box which indicates your age bracket on the day of completing this questionnaire.

- ☐ 20-24
- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ 40-44
- ☐ 45-49
- ☐ 50-54
- ☐ 55-59
- ☐ 60+

3. Please tick the box that best applies. How long have you been qualified as a Chartered Physiotherapist?
☐ Under 1 year ☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ 21-25 years ☐ 26-30 years ☐ Over 30 years
4. Please tick the box that best applies. How many years have you worked in Football? (Please count all years
☐ Under 1 year ☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ 21-25 years ☐ 26-30 years ☐ Over 30 years

6.4 Pilot Survey

Prior to the start of the *Phase 2*, the online survey was piloted and reviewed by 2 clinicians for ease of use and for establishing the time it would take to complete the study (Struyf et al, 2012; You et al, 2012; Fan and Yan, 2010). The clinicians both reported the questionnaire to be easy to understand and access. All online links worked and the online tool ensured all items had been completed before the next section of the survey could be completed. This is important as Fan & Yan (2010) report technical failure of online surveys significantly decreases the response rate. At this time it was also established that it should take no longer than 10 minutes to complete the online survey which is important as surveys taking over 30 minutes to complete have also been found to have decreased response rate (Fan and Yan, 2010; Randelli et al, 2012).

6.5 Participants and Recruitment

Phase 2 recruited Chartered Physiotherapists currently working in non-Premiership football. English Premier Football League Physiotherapists were excluded from *Phase 2* as this group was used to develop the tool in *Phase 1*. Potential participants were contacted via email (Appendix 12), postal invite (Appendix 13) and twitter with information (Appendix 14) regarding the study. Participants had to actively opt in to take part in this study. Contact information for the Physiotherapist was gained from the club websites and through member searches on twitter. This included the Championship, League 1, League 2, Football Conference Premiership, Football Conference North and Football Conference South. Where possible the invitation was addressed directly to the club Physiotherapist if their name was known as personalised invites have been shown to increase response rate (You et al, 2012; Sahlqvist et al, 2011; Fan and Yan, 2010; Dillman, 2000). A reminder email and postal invite were also sent out to maximise potential response rates (You et al, 2012; Sahlqvist et al, 2011; Fan and Yan, 2010; Kaplowitz et al, 2004; Dillman, 2000).

6.6 Ethical Issues

Prior to the start of *Phase 2*, ethical approval was gained from the Built, Sport and Health (BuSH) Ethics Committee, University of Central Lancashire, reference number BuSH 160 (Appendix 15). Ensuring and maintaining confidentiality and anonymity were imperative in this study. Information sharing in professional football is not common practice as clubs are competing against each other and strive to be ahead of the competition. The questionnaire did not record the participants' personal details and all responses were automatically anonymised in *Phase 2*. Each participant had access to an information sheet (Appendix 14) with details of the research process before opting to participate. Participants had to actively opt in to take part in this phase of the study and participants were given the opportunity to withdraw from the study at any time. Participants were informed that any data collected before this point would still be used but would not be identifiable as it was collected anonymously. Demographic data was collected to describe the participant set that took part in this study. All data collected has been kept in a locked filing cabinet or on personal computer files that are password protected. Data has been stored at UCLAN in line with University policy. Only the researcher and the supervisory team of the project have access to personal data/information.

6.7 Data Storage

As with *Phase 1* of the study, all data has been stored in accordance with UCLAN regulations. Electronic data has been stored on password-protected computers. Data will be kept for 5 years following the study, and then destroyed.

6.8 Analysis

A 5-point likert scale was used to determine agreement levels for a testing being included in the Functional Movement Screening Tool for Football (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al, 2012; Thomas et al, 2011. The scale was scored in the following way: Strongly Agree (1.0), Agree (2.0) Neither Agree or Disagree (3.0), Disagree (4.0) and Strongly Disagree (5.0). As a standardised agreement threshold for including items into a screening tool does not exist, as seen in previous healthcare literature a threshold level of below 3.0 was used to define agreement and establish inclusion in the final screening tool (Mercer et al, 2007; Weidner & Henning, 2004; Duffield, 1994). Further information on determining the threshold criterion is discussed in Section 8.2. Descriptive statistics were used to describe the participant set and data collected from the online questionnaire survey. These have been displayed in tables, graphs and text to illustrate the results. Before the data collected from twitter was combined with the results obtained via email and postal invites, the stability of the data was reviewed for consistency.

7.0 CHAPTER SEVEN RESULTS OF *PHASE 2*

7.1 Participant Information

A total of 26 Physiotherapists working in non-premiership football participated in *Phase 2* of this study. Figure 3 shows the breakdown of which level of football they were working in at the time of completing the survey. Participants ranged from a minimum age bracket of 20-24 years to a maximum of 45- 49 years old. The modal age bracket was 30-34 years old with 8 participants falling into this range.

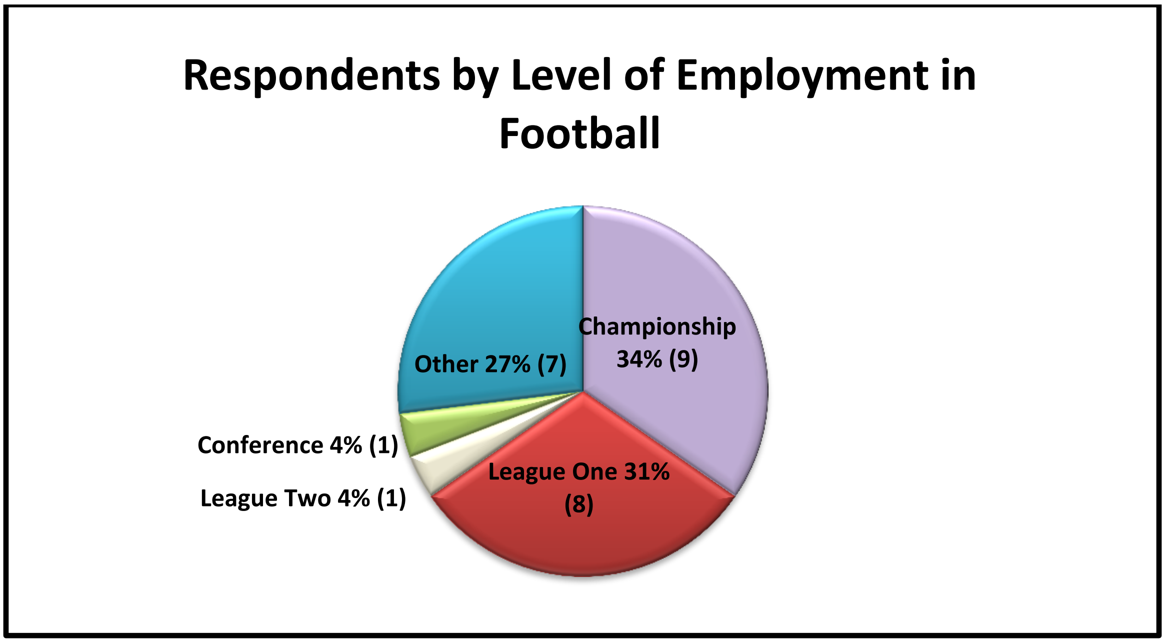

Figure 3 Respondents by Level of Employment in Football

Table 8 shows the number of years each participant reported being qualified as a Chartered Physiotherapist. A total of 5 Physiotherapists reported being qualified for less than 1 year. No participants reported being qualified for 26 years or higher. The mode of years qualified was the 6-10 year bracket with 10 participants in this group.

Table 8 Years Qualified as a Chartered Physiotherapist

	Less than 1 Year	1-5 Years	6-10 Years	11-15 Years	16-20 Years	21-25 Years
Championship	0	1	2	3	1	2
League One	2	1	4	1	0	0
League Two	1	0	0	0	0	0
Conference	0	0	1	0	0	0
Other	2	2	3	0	0	0
Response Totals	5	4	10	4	1	2

Interestingly Table 9 shows only 2 Physiotherapists reported working in football for less than 1 year despite 5 Physiotherapists reporting they had been qualified for less than 1 year. The 1-5 year bracket for years worked in football was the mode range with 10 Physiotherapists in this category.

Table 9 Number of Years Worked in Football

	Less than 1 Year	1-5 Years	6-10 Years	11-15 Years	16-20 Years
Championship	0	3	3	3	0
League One	0	4	2	1	1
League Two	0	1	0	0	0
Conference	0	0	1	0	0
Other	2	2	3	0	0
Response Totals	2	10	9	4	1

Individual test results will be presented in the tables below. The overall agreement levels will be displayed first and then the results are broken down into response by level of employment in the football league. Although some columns may contain a number of zeros, due to the perceived hierarchy in sport it is important to review responses by league as well as the overall combined data. The zero columns have not been collapsed in order to present all data consistently.

7.2 Overall Results

Table 10 shows the overall combined results for the evaluation of the tests to be included in a Functional Movement Screening Tool for Football. An agreement level of below 3.0 was used to establish the threshold criterion for inclusion into the final screening tool. The single-leg squat test showed the highest level of agreement at an overall average rating of 1.46. The piriformis and soleus tests received an overall average rating of 3.00 or above and would not be included in the Functional Movement Screening Tool for Football.

Table 10 Overall Responses to Each Test included in the Functional Movement Screening Tool for Football

Overall Responses to the test included in the Functional Movement Screening Tool for Football						
	Strongly Agree (1.0)	Agree (2.0)	Neither Agree/ Disagree (3.0)	Disagree (4.0)	Strongly Disagree (5.0)	Rating Average
Single-leg Squat	14	12	0	0	0	1.46
Deep Squat	8	14	4	0	0	1.85
In-line Lunge	9	13	3	0	1	1.88
Y-Balance Test	4	15	3	3	1	2.31
Modified Thomas Test	8	10	1	4	3	2.38
Internal Rotators of the Hip Assessment	5	11	6	2	2	2.42
Vertical Jump	7	7	6	5	1	2.46
External Rotators of the Hip Assessment	3	12	7	2	2	2.54
Adductor/Groin Flexibility Test	3	12	3	6	2	2.69
Gastrocnemius Test	2	8	8	5	3	2.96
Piriformis Test	1	9	8	5	3	3.00
Soleus Test	0	10	8	5	3	3.04

7.3 Individual Test Break Down

7.3.1 Results for the Single-leg Squat

Table 11 shows the combined results for the evaluation of the single-leg squat. With an average rating of 1.46 the test is below the 3.00 threshold and would be included in the final screening tool. This is the only test where all participants either strongly agreed or agreed with including this test in the Functional Movement Screening Tool for Football.

Table 11 Combined Results for the Single-leg Squat

Do you think the Single-leg Squat should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average
14	12	0	0	0	1.46

Table 12 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. Physiotherapists working in League Two and the Conference had an overall rating average of 1.00 showing strong agreement with including a single-leg squat in the Functional Movement Screening Tool for Football. Physiotherapists working in the Championship, League One and Other leagues all had an overall rating below 2.00 showing agreement with including the single-leg squat.

Table 12 Results for the Single-leg Squat by Level of Football Employment

Do you think the Single-leg Squat should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	6	3	0	0	0	1.33	9
League One	4	4	0	0	0	1.5	8
League Two	1	0	0	0	0	1.00	1
Conference	1	0	0	0	0	1.00	1
Other	2	5	0	0	0	1.71	7
Response Totals	14	12	0	0	0	1.46	26

7.3.2 Results for the Deep Squat

Table 13 shows the combined results for the evaluation of the deep squat. With an average rating of 1.85 the test is below the 3.00 threshold and would be included in the final screening tool. No participants disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 13 Combined Results for the Deep Squat

Do you think the Deep Squat should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average
8	14	4	0	0	1.85

Table 14 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. Physiotherapists working in the Championship had an overall rating average of 1.67 showing the strongest agreement with including a deep squat in the Functional Movement Screening Tool for Football. Physiotherapists working in League One, League Two and the Conference all had an overall rating of 2.00 still also showing agreement with the inclusion of the deep squat.

Table 14 Results for the Deep Squat by Level of Football Employment

Do you think the Deep Squat should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	4	4	1	0	0	1.67	9
League One	2	4	2	0	0	2.00	8
League Two	0	1	0	0	0	2.00	1
Conference	0	1	0	0	0	2.00	1
Other	2	4	1	0	0	1.86	7
Response Totals	8	14	4	0	0	1.85	26

7.3.3 Results for the In-line Lunge

Table 15 shows the combined results for the evaluation of the in-line lunge. With an average rating of 1.88 the test is below the 3.00 threshold and would be included in the final screening tool. Notably one person strongly disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 15 Combined Results for the In-line Lunge

Do you think the In-line Lunge should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average
9	13	3	0	1	1.88

Table 16 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. Physiotherapists working in the Championship had an overall rating average of 1.78 showing the strongest agreement with including an in-line lunge in the Functional Movement Screening Tool for Football. Physiotherapists working in Other leagues still had an overall rating of 2.00 showing agreement with the inclusion of the in-line lunge despite one participant strongly disagreeing with including this test.

Table 16 Results for the In-Line Lunge by Level of Football Employment

Do you think the In-line Lunge should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	3	5	1	0	0	1.78	9
League One	3	3	2	0	0	1.88	8
League Two	0	1	0	0	0	2.00	1
Conference	0	1	0	0	0	2.00	1
Other	3	3	0	0	1	2.00	7
Response Totals	9	13	3	0	1	1.88	26

7.3.4 Results for the Y-Balance Test

Table 17 shows the combined results for the evaluation of the Y-balance test. With an average rating of 2.31 the test is below the 3.00 threshold and would be included in the final screening tool. For this test 3 participants disagreed and 1 participant strongly disagreed with including the Y-balance test.

Table 17 Combined Results for the Y-Balance Test

Do you think the Y-Balance Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average
4	15	3	3	1	2.31

Table 18 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. Physiotherapists working in League One, League Two and the Conference had the lowest overall rating average of 2.00 showing agreement with including the Y-balance test in the Functional Movement Screening Tool for Football. Physiotherapists working in the Championship and Other leagues still had an overall rating below 3.00 therefore agreeing with the Y-balance test being included in the Functional Movement Screening Tool for Football despite one participant strongly disagreeing and 3 participants disagreeing with including this test.

Table 18 Results for the Y-Balance Test by Level of Football Employment

Do you think the Y-Balance Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	2	5	1	0	1	2.22	9
League One	1	6	1	0	0	2.00	8
League Two	0	1	0	0	0	2.00	1
Conference	0	1	0	0	0	2.00	1
Other	1	2	1	3	0	2.86	7
Response Totals	4	15	3	3	1	2.31	26

7.3.5 Results for the Modified Thomas Test

Table 19 shows the combined results for the evaluation of the modified Thomas test. With an average rating of 2.38 the test is below the 3.00 threshold and would be included in the final screening tool. Here 4 participants disagreed and 3 participants strongly disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 19 Combined Results for the Modified Thomas Test

Do you think the Modified Thomas Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
8	10	1	4	3	2.38

Table 20 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapists working in League One had the lowest rating average of 1.63 showing the strongest agreement with including the modified Thomas test in the Functional Movement Screening Tool for Football. The Physiotherapist working in League Two had an average rating of 5.00 showing this Physiotherapist strongly disagreed with the inclusion of the modified Thomas test.

Table 20 Results for the Modified Thomas Test by Level of Football Employment

Do you think the Modified Thomas Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	3	3	0	1	2	2.56	9
League One	3	5	0	0	0	1.63	8
League Two	0	0	0	0	1	5.00	1
Conference	0	0	1	0	0	3.00	1
Other	2	2	0	3	0	2.57	7
Response Totals	8	10	1	4	3	2.38	26

7.3.6 Results for the Internal Rotators of the Hip Assessment

Table 21 shows the combined results for the evaluation of the internal rotators of the hip assessment. With an average rating of 2.42 the test is below the 3.00 threshold and would be included in the final screening tool. For this test 2 participants disagreed, 2 participants strongly disagreed and 6 neither agreed nor disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 21 Combined Results for the Internal Rotators of the Hip Assessment

Do you think the Internal Rotators of the Hip Assessment should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
5	11	6	2	2	2.42

Table 22 shows Physiotherapists working in League One had the lowest overall rating average of 1.75 showing the strongest agreement with including the internal rotators of the hip assessment in the Functional Movement Screening Tool for Football. Physiotherapists working in the Championship had an overall rating of 2.89 showing this group of Physiotherapists agreed with the internal rotators of the hip assessment being included despite 2 Physiotherapists strongly disagreeing and 1 disagreeing with its inclusion.

Table 22 Results for the Internal Rotators of the Hip Assessment by Level of Football Employment

Do you think the Internal Rotators of the Hip Assessment should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	2	2	2	1	2	2.89	9
League One	2	6	0	0	0	1.75	8
League Two	0	1	0	0	0	2.00	1
Conference	0	0	1	0	0	3.00	1
Other	1	2	3	1	0	2.57	7
Response Totals	5	11	6	2	2	2.42	26

7.3.7 Results for the Vertical Jump Test

Table 23 shows the combined results for the evaluation of the vertical jump test. With an average rating of 2.46 the test is below the 3.00 threshold and would be included in the final screening tool. Here 5 participants disagreed and 1 participant strongly disagreed with including this test. Notably 6 participants also selected neither agree nor disagree with the inclusion of this test.

Table 23 Combined Results for the Vertical Jump Test

Do you think the Vertical Jump Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average
7	7	6	5	1	2.46

Table 24 shows the Physiotherapist working in the Conference had the lowest rating of 1.00 showing strong agreement with including the vertical jump test in the Functional Movement Screening Tool for Football. Physiotherapists working in the Championship, League One and Other leagues still had an overall rating below 3.00 therefore agreeing with the vertical jump test being included. The Physiotherapist working in League Two had the only rating average of 5.00 therefore strongly disagreeing with inclusion of this test.

Table 24 Results for the Vertical Jump Test by Level of Football Employment

Do you think the Vertical Jump Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	2	2	2	3	0	2.67	9
League One	3	2	2	1	0	2.13	8
League Two	0	0	0	0	1	5.00	1
Conference	1	0	0	0	0	1.00	1
Other	1	3	2	1	0	2.43	2
Response Totals	7	7	6	5	1	2.46	26

7.3.8 Results for the External Rotators of the Hip Assessment

Table 25 shows the combined results for the evaluation of the external rotators of the hip assessment. With an average rating of 2.54 the test is below the 3.00 threshold and would be included in the final screening tool. For this test 2 participants disagreed, 2 participants strongly disagreed and 6 neither agreed nor disagreed with including the external rotators of the hip assessment.

Table 25 Combined Results for the External Rotators of the Hip Assessment

Do you think the External Rotators of the Hip Assessment should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
3	12	7	2	2	2.54

Table 26 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapist working in League Two had the lowest rating average of 1.00 showing strong agreement with including the external rotators of the hip assessment. Physiotherapists working in the Championship and the Conference had an overall rating of 3.00 showing this group of Physiotherapists neither agreed nor disagreed with the inclusion of the external rotators of the hip assessment.

Table 26 Results for the External Rotators of the Hip Assessment by Level of Football Employment

Do you think the External Rotators of the Hip Assessment should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	1	3	2	1	2	3.00	9
League One	0	7	1	0	0	2.13	8
League Two	1	0	0	0	0	1.00	1
Conference	0	0	1	0	0	3.00	1
Other	1	2	3	1	0	2.57	7
Response Totals	3	12	7	2	2	2.54	26

7.3.9 Results for the Adductor/Groin Flexibility Test

Table 27 shows the combined results for the evaluation of the adductor/groin flexibility test. With an average rating of 2.69 the test is below the 3.00 threshold and would be included in the final screening tool. For this test 6 participants disagreed and 2 participants strongly disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 27 Combined Results for the Adductor/Groin Flexibility Test

Do you think the Adductor/Groin Flexibility Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
3	12	3	6	2	2.69

Table 28 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapist working in League Two had the lowest rating average of 1.00 showing strong agreement with including the adductor/groin flexibility test. Physiotherapists working in the Championship had an overall rating of 3.44 therefore showing this group of Physiotherapists did not agree with the adductor/groin flexibility Test being included in the Functional Movement Screening Tool for Football.

Table 28 Results for the Adductor/Groin Flexibility Test by Level of Football Employment

Do you think the Adductor/Groin Flexibility Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	1	2	0	4	2	3.44	9
League One	0	6	2	0	0	2.25	8
League Two	1	0	0	0	0	1.00	1
Conference	0	0	1	0	0	3.00	1
Other	1	4	0	2	0	2.43	7
Response Totals	3	12	3	6	2	2.69	26

7.3.10 Results for the Gastrocnemius Test

Table 29 shows the combined results for the evaluation of the gastrocnemius test. With an average rating of 2.96 the test is below the 3.00 threshold and would be included in the screening tool. For this test 3 participants strongly disagreed, 5 participants disagreed and 8 participants neither agreed nor disagreed with including the gastrocnemius test in the Functional Movement Screening Tool for Football.

Table 29 Combined Results for the Gastrocnemius Test

Do you think the Gastrocnemius Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
2	8	8	5	3	2.96

Table 30 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapists working in League One had the lowest rating average of 2.50 showing the strongest agreement with including the gastrocnemius test. The Physiotherapist working in League Two had a rating of 5.00 showing this Physiotherapist again strongly disagreed with the gastrocnemius test being included in the Functional Movement Screening Tool for Football.

Table 30 Results for the Gastrocnemius Test by Level of Football Employment

Do you think the Gastrocnemius Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	0	3	1	3	2	3.44	9
League One	0	4	4	0	0	2.50	8
League Two	0	0	0	0	1	5.00	1
Conference	0	0	1	0	0	3.00	1
Other	2	1	2	2	0	2.57	7
Response Totals	2	8	8	5	3	2.96	26

7.3.11 Results for the Piriformis Test

Table 31 shows the combined results for the evaluation of the piriformis test. With an average rating of 3.00 the test is equal to the 3.00 threshold and would be excluded from the final screening tool. For this test 3 participants strongly disagreed, 5 participants disagreed and 8 participants neither agreed or disagreed with including this test in the Functional Movement Screening Tool for Football.

Table 31 Combined Results for the Piriformis Test

Do you think the Piriformis Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
1	9	8	5	3	3.00

Table 32 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapists working in the Other category had an overall rating average of 2.57, the only group having an average rating below 3.00. The Physiotherapist working in League Two again had an overall rating of 5.00 showing this Physiotherapist strongly disagreed with the piriformis test being included in the Functional Movement Screening Tool for Football.

Table 32 Results for the Piriformis Test by Level of Football Employment

Do you think the Piriformis Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	0	4	2	1	2	3.11	9
League One	0	2	4	2	0	3.00	8
League Two	0	0	0	0	1	5.00	1
Conference	0	0	1	0	0	3.00	1
Other	1	3	1	2	0	2.57	7
Response Totals	1	9	8	5	3	3.00	26

7.3.12 Results for the Soleus Test

Table 33 shows the combined results for the evaluation of the soleus test. With an average rating of 3.04 the test is above the 3.00 threshold and would not be included in the final screening tool. Here 3 participants strongly disagreed, 5 participants disagreed and 8 participants neither agreed nor disagreed with including the soleus test in the Functional Movement Screening Tool for Football. Notably no Physiotherapist strongly agreed with the inclusion of this test.

Table 33 Combined Results for the Soleus Test

Do you think the Soleus Test should be in a Functional Movement Screening Tool for Football?					
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Rating Average
0	10	8	5	3	3.04

Table 34 shows the breakdown of results in relation to the level of football where the Physiotherapist is currently working. The Physiotherapists working in League One had the lowest overall rating average of 2.50 showing the strongest agreement with including the soleus test. The Physiotherapist working in League Two had an overall rating of 5.00 showing this Physiotherapist once again strongly disagreed with the soleus test being included in the Functional Movement Screening Tool for Football.

Table 34 Results for the Soleus Test by Level of Football Employment

Do you think the Soleus Test should be included in a Functional Movement Screening Tool for Football?							
	Strongly Agree	Agree	Neither Agree/ Disagree	Disagree	Strongly Disagree	Rating Average	Answered Questions
Championship	0	3	1	3	2	3.44	9
League One	0	4	4	0	0	2.50	8
League Two	0	0	0	0	1	5.00	1
Conference	0	0	1	0	0	3.00	1
Other	0	3	2	2	0	2.86	1
Response Totals	0	10	8	5	3	3.04	26

<u>8.0 CHAPTER EIGHT DISCUSSION *PHASE 2*</u>

<u>8.1 *Phase 2* Responses</u>

A total of 26 participants completed the online survey in *Phase 2* of this study. Of the participants initially contacted through club websites, only 2 Physiotherapists completed the online questionnaire within a 4 week period. As response rates in *Phase 1* were successful, it was suspected that the information was not being passed on to the Physiotherapists therefore postal invites were also sent out to the 140 clubs addressed: FAO Club Physiotherapist. This method only recruited 8 additional participants in a further 4 week period. Again, this was surprising due to the successful recruitment in *Phase 1*. At this point, a decision was made to try another recruitment strategy to ensure a number of options for recruitment had been exhausted. As twitter has become increasingly popular, especially in the sport and football world, this social network was accessed to advertise this study and potentially recruit further participants.

Twitter proved to be a valuable tool for participant recruitment in this study. Within the first hour of tweeting the study details, 14 people re-tweeted the information and by the end of the first day 10 people had completed the online questionnaire. Over a three week time period, the study information was posted 10 times from the researcher and re-tweeted 43 times by other users leading to 16 total completions through twitter in three weeks, which was more than the number of participants recruited in over an 8 week period through email and postal invites. The success of Twitter for recruitment purposes raises the question if this resource may be useful for distributing the Functional Movement Screening Tool for Football to this specific population as emails and postal contact had limited success.

8.2 Determination of Threshold Level for Agreement

Currently there are no set guidelines for a threshold level which determines agreement on a likert scale. This creates a problem with a 5-point likert scale as to whether or not the neutral column of neither agree nor disagree is considered as agreement or disagreement. It could be argued that by selecting the neutral column the Physiotherapist did not feel strongly enough to disagree with inclusion of the test and therefore the neutral column could be more on the side of agreement. However, it also means the Physiotherapist did not feel strongly enough to select it for inclusion and therefore it does not indicate agreement. On analysis of the results, if only those who agreed or strongly agreed with the tests inclusion in the screening tool, the threshold for inclusion would be set at under 2.0. This would mean that only three tests; the single-leg squat, deep squat and in-line lunge would be included in the Functional Movement Screening Tool for Football as all other tests had an overall rating average above 2.0. If the neutral category was viewed as showing agreement, the threshold would be set at below 3.0 and this would see a further 7 tests included in the screening tool. This would take the total to 10 tests being included in the Functional Movement Screening Tool for Football. Two tests, the piriformis test and the soleus test had an overall average rating scores were equal to or above 3.0 and would therefore not be included in the screening tool.

The 75% threshold criterion used in *Phase 1* of this study was also considered when trying to establish the threshold level for agreement in *Phase 2*. However, in *Phase 1* of this study participants were only asked to select yes or no if they agreed with including the test in the Functional Movement Screening Tool for Football, they were not asked to select the level in which they agreed with the test being included. If the same 75% threshold level was applied in *Phase 2*, this would mean at least 20 participants had either agreed or strongly agreed with the test being included in the screening tool. This would again result in only the single-leg squat, in-line lunge and deep squat being included in the final Functional Movement Screening Tool for Football (Table 10).

When evaluating other screening batteries, there is some variation in the number of tests included in the tool. This ranged from 7 to 22 (Frohm et al, 2011; Rosch et al, 2011; Mottram and Comerford, 2007; Cook et al, 1998). It would prove quite difficult to screen athletes only using 3 tests. Therefore a decision was made to use the below 3.0 overall rating average threshold for inclusion in the Functional Movement Screening Tool for Football. As Physiotherapists who selected the neutral category did not feel strongly enough to disagree with the test being included, this study included the neutral category in the agreement threshold level. This resulted in 10 tests being included in the final Functional Movement Screening Tool for Football: single-leg squat, deep squat, in-line lunge, Y-balance test, modified Thomas test, internal rotators of the hip assessment, vertical jump test, external rotators of the hip assessment, adductor/groin flexibility test and the gastrocnemius test.

8.3 Tests With an Overall Average Rating Below 2.0

Only three tests had an overall average rating below 2.0 which indicates the majority of participants in *Phase 2* agreed with the tests being included in the Functional Movement Screening Tool for Football. These tests are the single-leg squat (1.46), deep squat (1.85) and in-line lunge (1.88). Interestingly the single-leg squat had the highest level of agreement score but this test was only found in one of the football screening tools in the literature. Both the deep squat and in-line lunge are from the Functional Movement Screen (Cook et al, 1998) and were the only two tests from the FMS to be included in the final Functional Movement Screening Tool for Football.

8.3.1 Single-leg Squat

The single-leg squat had the highest level of agreement (1.46) in *Phase 2* and was the only test to have all participants either agree or strongly agree with its inclusion (Table 11). The single-leg squat did not have the highest selection percentage in *Phase 1A*. It was select by 87.5% of participants in *Phase 1A* and was behind the in-line lunge and modified Thomas test which were both selected for inclusion by 100% of participants. However, overall there was consistency in participants from both phases with including this test in the Functional Movement Screening Tool for Football.

The single-leg squat is designed to assess overall neuromuscular control, core stability, dynamic flexibility and balance (Clark and Lucett, 2010; Reiman and Manske, 2009; Liebenson, 2002). For the test, the athlete is instructed to start by adopting a single-leg stance on the test leg with the non-test knee bent at 90 degrees behind the body. The athlete is then asked to place their hands on their hips and keep the upper body and trunk upright throughout the movement. Finally the athlete is instructed to squat down as far as they are capable by bending at the hip, knee and ankle but not the trunk (Ageberg, Bennell, Hunt, Simic, Roos and Creaby, 2010; Clark and Lucett, 2010). Clark and Lucett (2010) state the test should be performed without shoes allowing for the foot biomechanics to be monitored. Although a standardised scoring system does not exist for this movement the angle of knee flexion obtained during the single-leg squat can be recorded (Kivlan and Martin, 2012; Reiman and Manske, 2009). Clark and Lucett (2010) suggest up to 5 repetitions should be assessed and only movements where the knee has remained in line with second toe should be recorded and the athlete should be able to achieve hip flexion (65º) with hip adduction and knee valgus not exceeding 10º (Kivlan and Martin, 2012). With regards to football, the single-leg squat relates to both deadball kicking and dynamic kicking movements as well as single leg landing from a jump and single-leg cross-cutting manoeuvres (Sannicandro, Rosa, De Pascalis and Piccinno, 2012; Requena et al, 2009; Wilson, Ireland and Davis, 2006).

Poor performance on this test may present with knee valgus during the movement which has been associated with reduced hip abductor and external rotation strength, over-activity of the hip adductors and limited ankle dorsiflexion (Crossley, Zhang, Schache, Bryant and Cowan, 2011; Bailey, Selfe and Richards, 2010; Clark and Lucett, 2010; Wilson et al, 2006). Liebenson (2002) also state that the Single-leg Squat is capable of identifying a number of kinetic chain dysfunctions including pelvic unleveling, excessive trunk flexion, poor knee control and subtalar hyerpronation. This may be due to pelvic dysfunction, a tight soleus, gluteus medius or maximus insufficiency or a combination of these dysfunctions (Liebenson, 2002). Despite the fact a single-leg squat may identify a number of dysfunctions; there is no literature which suggests any particular injuries may occur as a result of poor performance on this test. This is likely to be due to the multi-factorial nature of the test as it assesses multiple joint segments during the movement (Crossley et al, 2011; Clark and Lucett, 2010). Although there is no direct evidence linking a single leg-squat ability to predict any specific injuries, some literature has reported a correlation between single-leg squat performance and anterior knee pain and ACL injuries (Jennison, Barton, Crossley and Pizzari, 2010; Levinger, Gilleard and Coleman, 2007; Wilson et al, 2006). The single-leg squat has also been included in the FIFA 11+ injury prevention exercises therefore further supporting its relevance in football (FIFA, 2009). Therefore the test may also serve as an important bench mark during rehabilitation and return to sport. This is of particular importance as previous injury is a known injury risk factor in football (Ekstrand et al, 2011; Ekstrand et al, 2009; Engebretsen et al, 2008; Junge et al, 2002).

Correct execution of the single-leg squat is not as well documented and little evidence is available to support the validity of the single-leg squat in relation to hip strength assessment and injury prediction (Bailey et al, 2010). Although the test was developed by Liebenson (2002), Livengood, DiMattia and Uhl (2004) were the first to describe a scoring system for the single-leg squat. Livengood et al (2004) defined excellent performance as the ability to achieve hip flexion (65º), hip adduction not exceeding 10º and knee valgus/varus not exceeding 10º. Good performance met the any of the 2 set criterions, fair performance meeting one of the criterions and poor performance not meeting any of the criterion or a loss in balance (Livengood et al, 2004). To assess the validity of the devised scoring system, DiMattia, Livengood, Uhl, Mattacola and Malone (2005) studied 50 healthy participants performing a single-leg squat using the excellent-poor scale they previously developed (Livengood et al, 2004). The results of the single-leg squat were then compared to hip abductor strength that had been previously measured in side-lying with a hand held dynamometer. DiMattia et al (2005) reported a weak positive correlation between the two variables (r=0.21) and concluded that in healthy individuals single-leg squat performance has limited ability to assess abductor strength.

Frohm et al (2011) included the single-leg squat in their nine-test screening battery which was designed specifically for football players. A total of 18 football players were recorded performing the single-leg squat as well as 8 other tests. Frohm et al (2011) reported poor inter-rater reliability for this test (ICC=0.53). As the test requires multiple joint stability and coordination, Frohm et al (2011) found the test challenging to score. This may be one reason it is not currently found in other football screening tools. Although Frohm et al (2011) used an adapted version of Cook et al's (2003) 4 point scoring system; they did not describe what was classified as correct movement for the single-leg squat leaving the correct performance open to reader interpretation and reducing the studies reproducibility.

The inter-rater reliability of the single-leg squat has been examined in a number of non-football related studies. This has been performed in the normal population and in other sporting populations (Kivlan and Martin, 2012). Crossley et al (2011) has reported good to excellent intra-rater reliability (ICC=0.61-0.80) of the single-leg squat with using specific criteria of achieving hip flexion (=65º), hip adduction (≤10º) and knee valgus (≤10º) (Livengood and DiMattia, 2004). DiMattia et al (2005) used the same criteria as Crossley et al (2011) and reported low to moderate inter-rater reliability (k=0.11 and k=0.31).

8.3.2 Deep Squat

The deep squat was selected to be included in the screening tool by 87.5% of participants in *Phase 1A*. In *Phase 2* it received the second highest agreement score (1.85) leading to inclusion in the final screening tool. Although 3 participants neither agreed nor disagreed with including this test, no participants disagreed with its inclusion (Table 13). Therefore this indicated that both groups of participants agreed this test should be included in the functional screening tool. The deep squat is a movement needed in a number of activities of daily living and in sporting performance (Kritz, Cronin and Hume, 2009; Cook et al, 2006a; Cook, 2003). In football, the deep squat replicates the movements of preparing for a jump and landing in outfield players and preparation of a dive in goal keepers (Lees and Nolan, 1998). During a deep squat the entire body mechanics are challenged during correct execution of this movement (Kritz et al, 2009; Cook et al, 2006a; Cook, 2003). Not only does the movement evaluate symmetry and functional mobility and dynamic muscle length around the hip, knee and ankles, with a dowel placed overhead, the shoulder and thoracic spine are also assessed (Kritz et al, 2009; Cook et al, 2006a; Cook, 2003).

Although the deep squat is mentioned in many books and research papers, a number of these have used the definition set out by the FMS to evaluate the movement (Butler, Plisky, Southers, Scoma, and Kiesel, 2010; Clark and Lucett, 2010). Figure 4 below illustrates the movement and the scoring system developed by Cook et al (2006a; Cook, 2003) is found in Table 3, section 2.6. In order to perform the deep squat, the athlete stands with feet approximately shoulder width apart and they are asked to hold the dowel on their head and positions the elbows at 90 degrees. The athlete is then asked to raise the arms above the head, extending the elbows (Cook et al, 2006a; Cook, 2003). The athlete is then instructed to slowly descend into a squat position keeping both heels on the ground and maintaining the overhead dowel position (Cook et al, 2006a; Cook, 2003). Cook et al (2006a) state up to three repetitions may be performed whereas other authors have allowed two trials prior to the scoring of the three repetitions (Onate et al, 2012). It is scored from 0-3 depending on the athlete's ability to perform the movement (Cook et al, 2006a). Correct performance of the movement relies on coordination of the closed kinetic chain activities of ankle dorsiflexion, knee and hip flexion, thoracic extension and abduction and flexion of the shoulders (Butler et al, 2010; Kritz et al, 2009; Cook et al, 2006a). Therefore the test examines the coordination of mobility and strength throughout the entire kinetic chain in incremental stages throughout the movement (Butler et al, 2010).

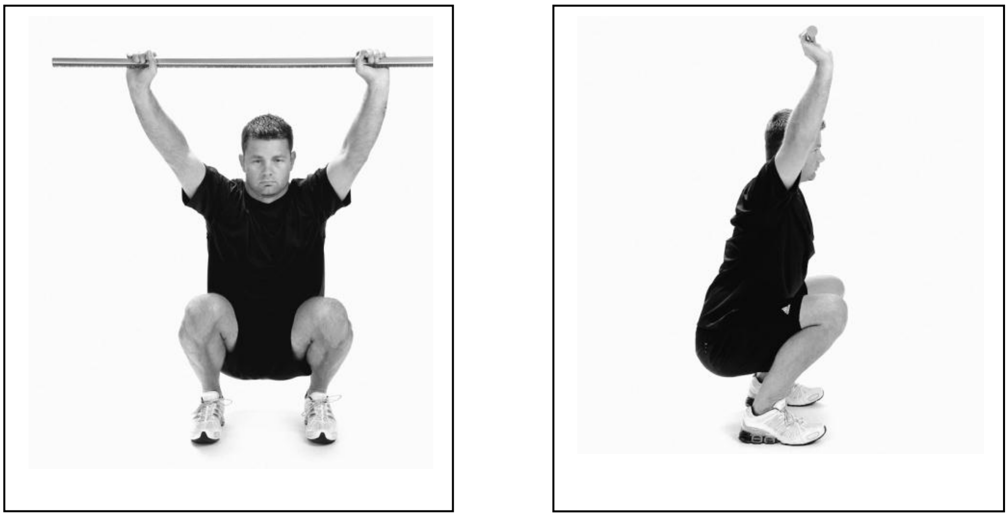

Figure 4 Deep Squat (Cook, 2003)

Cook et al (2006a) claim that poor performance on the deep squat movement can be caused by a number of different factors. In particular, reduced thoracic and glenohumeral mobility can lead to decreased upper torso movement. In the lower extremity, restriction in weight bearing dorsiflexion may attribute to poor test performance. Cook et al (2006a) also believe poor performance on the test could lead to an increase risk of injury. Clark and Lucett (2010) agree that movement impairments on the deep squat elevating injury risk as joint motion, muscle activation and neuro-muscular control may be altered with poor movement performance. Although a number of studies have looked collectively at the FMS's ability to predict injury, only one study was found that directly linked each individual test's ability to predict injury (Kiesel et al, 2009). Although Kiesel et al (2009) found performance on a squat was a key indicator for potential injury; specific injuries again have not been identified with poor squat performance. As a deep squat involves a series of movements involving the entire kinetic chain, a number of dysfunctions may occur. Literature that has investigated the FMS or deep squat's ability to predict injury has only reported if a player sustained an injury or not. The mechanism and types of injury were not recorded.

Frohm et al (2011) reported the inter-rater reliability of the assessment of the FMS deep squat performed in real-time to be good (ICC=0.73) in 18 footballers assessed by 8 different Physiotherapists. Whereas Parenteau, Gaudreult, Chambers, Boisvert, Grenier, Gagne and Balg (2013) also reported good agreement of the intra-rater (k=0.78) and inter-rater reliability (k=0.75) with the videoed FMS deep squat in 28 elite hockey players. Teyhen, Shaffer, Lorenson, Halfpap, Donofry, Walker, Dugan and Childs (2012) also evaluated the real-time reliability of assessing the FMS deep squat in 64 active-duty servicemen. Teyhen et al (2012) reported only substantial inter-rater reliability (k=0.68) and substantial intra-rater reliability (k=0.76) with the deep squat scored by novice raters. On the lower end of the spectrum, Shultz, Anderson, Matheson, Marcello and Besier (2013) reported low inter-rater reliability (ICC=0.41) when assessing 39 male and female collegiate athletes FMS recordings. The variation in reliability results demonstrate the scoring system for the deep squat may not be sensitive or clear enough for raters to agree on each scoring criteria.

8.3.3 In-line Lunge

The in-line lunge was selected by 100% of participants in *Phase 1A* and had an overall agreement rating of 1.88 in *Phase 2*. Although 1 participant strongly disagreed with its inclusion in *Phase 2*, the majority of participants agreed that this test should be in the functional screening tool (Table 15). This data shows agreement from both groups for including the in-line lunge in the Functional Screening Tool for Football. The in-line lunge is the second and last test to be included from the well-recognised FMS testing battery.

The in-line lunge test is said to evaluate ankle, knee and hip mobility and stability, quadriceps flexibility by challenging the trunk and lower extremities to resist rotation and maintain alignment (Cook et al, 2006a; Cook, 2003). It is designed to assess functional asymmetries and simulates stresses placed on the body during deceleration, lateral movements and rotation (Cook et al, 2006a; Cook, 2003). Specifically for football this is also related to challenging for a ball, tackling, acceleration and deceleration of a sprint and throwing the ball back in to play (Sannicandro et al, 2012; Requena et al, 2009). As these movements require a split stance, the in-line lunge replicates these movements (Sannicandro et al, 2012; Requena et al, 2009; Lees and Nolan, 1998). As well as this, kicking a football requires hip stability and flexibility in coordination with trunk rotational stability, therefore the in-line lunge is considered to be an appropriate functional test in relation to a number of football skills (Sannicandro et al, 2012; Requena et al, 2009; Lees and Nolan, 1998). Sub-standard performance on this test can be linked to hip flexor tightness or asymmetry of mobility and stability of either one or both hips, with an imbalance frequently noted between abductor tightness and adductor weakness (Cook et al, 2006a; Cook, 2003). However, despite this information there is still no evidence directly linking poor performance to any particular injury patterns.

Although a lunge is mentioned in other screening tools and research papers, the in-line lunge originates from the FMS and therefore this test description has been used (Cook et al, 2006a; Cook, 2003). Figure 5 shows a diagram of the in-line lunge and the scoring system developed by Cook et al (2006a) and Cook (2003) can be found in Table 3, section 2.6. At the start of the in-line lunge, the athlete's tibial length is assessed using a tape measure. The athlete is then asked to stand with one foot at the end of the 2x6 board and the tibial length is marked out on the board from the big toe of the athlete's standing leg (Cook et al, 2006a; Cook, 2003). The athlete is then instructed to place a dowel behind their back with it touching their head, thoracic spine and sacrum, with the hand on top of the dowel being the same side as the back foot. The athlete is then asked to take a step and place the forward heel on the mark on the 2x6 board. Ensuring both feet are facing forwards and in line with each other, the athlete slowly performs a controlled lunge (Cook et al, 2006a; Cook, 2003). Cook et al (2006a) state up to three repetitions may be performed whereas other authors again have allowed two trials prior to the scoring of the three repetitions (Onate et al, 2012). It is scored from 0-3 depending on the athlete's ability to perform the movement (Cook et al, 2006a).

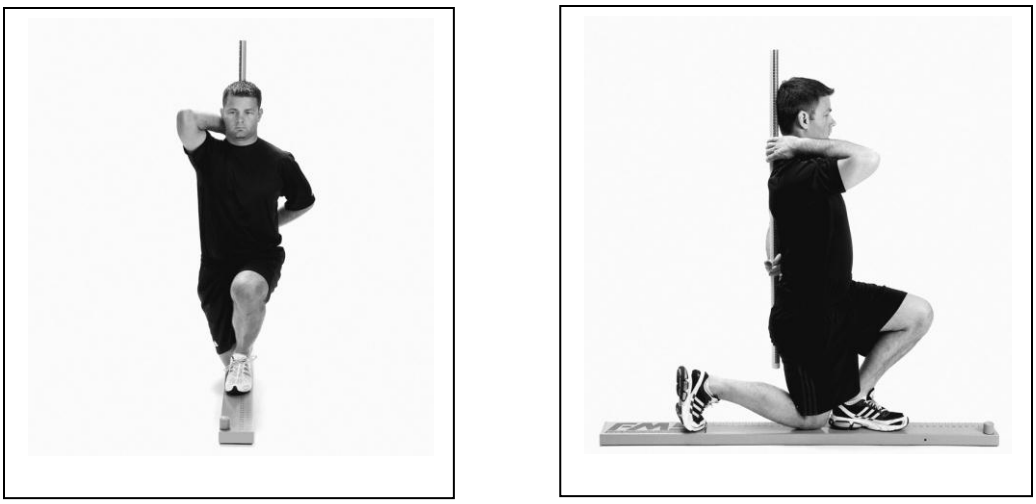

Figure 5 In-line Lunge (Cook, 2003)

Reliability testing of the in-line lunge has shown varying results in the literature. Frohm et al (2011) reported the real time inter-rater reliability to be good (ICC=0.74). However, Teyhen et al (2012) reported poor inter-rater reliability (k=0.45) and moderate intra-rater reliability (k=0.69) with the in-line lunge scored by novice raters. Parenteau et al (2013) reported substantial agreement (k=0.77) with the inter-rater and intra-rater (k=0.7) reliability of the assessment of the in-line lunge. Shultz et al (2013) reported the in-line lunge to have the lowest inter-rater reliability (ICC=0.10) of the 7 FMS tests. The large range of inter and intra-rater reliability results again highlight the need to review the scoring system for the in-line lunge.

Overall the inclusion of these 3 tests appears to be relevant for inclusion in the functional screening tool. The literature has shown correlation to football performance and a relationship with injury risk prediction in these tests (Sannicandro et al, 2012; Requena et al, 2009; Cook et al, 2006a). More importantly this study aimed to develop a functional screening tool and these 3 tests are classified as functional movements. However, standardised performance protocols and established sensitive scoring systems need to be developed to improve the reliability of each of the 3 tests.

8.4 Tests With an Overall Average Rating Below 3.0

In addition to the tests above, there were 7 tests which had an overall average rating below 3.0 and would be included in the Functional Movement Screening Tool for Football. This includes the Y-balance test (2.31), vertical jump test (2.46), adductor/groin flexibility test (2.69), internal rotators of the hip assessment (2.42), external rotators of the hip assessment (2.54), modified Thomas test (2.38) and the gastrocnemius test (2.96). Interestingly, these 7 tests are a combination of functional tests, performance tests and muscle length tests.

8.4.1 Y-balance Test

In the threshold band between 2.0 and below 3.0, the Y-balance test had the highest agreement score of 2.31. The Y-balance test was not on the first survey in *Phase 1A*. Instead the Y-balance test was added on participant request at the end of round one in *Phase 1A*. It was then included in the football screening tool as the test achieved a 75% selection, the minimum amount to be included in the tool in *Phase 1A*. The Y-balance test is a variation of the star excursion balance test and was designed to measure dynamic posture and balance (Butler, Southers, Gorman, Kiesel and Plisky, 2012; Plisky, Gorman, Butler, Kiesel, Underwood and Elkins, 2009). The Y-balance test requires specific testing equipment to be purchased (approximately £360.00) although some studies are reporting using tape to reproduce the test (Coughlan, Fullam, Delahunt, Gissane and Caufield, 2012).

The test starts with the athlete on the centre box which has three lines coming off of it; anterior line, posterolateral line & posteromedial line (Figure 6). The athlete stands with arms in a position of comfort and with one leg on the centre of the test platform with the furthest part of the toes on the starting line. Using the other foot, the athlete is instructed to reach as far as possible along each line pushing the reach indicator (Coughlan et al, 2012; Plisky et al, 2009). Four to six trials are performed to eliminate a learning effect, then the movements are performed and the furthest distance reached is recorded (Plisky et al, 2009). In order to standardise the procedure and reduce a fatiguing effect, the following test order is recommended: right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral and finally left posterolateral (Butler et al, 2012; Plisky et al, 2009). The test is considered invalid if the reach leg does not return to the start position, the reach foot is placed on the ground, if the reach indicator is used for stance support, contact with the reach indicator is lost or if the athlete raises or moves the stance foot during the test (Butler et al, 2012; Plisky et al, 2009).

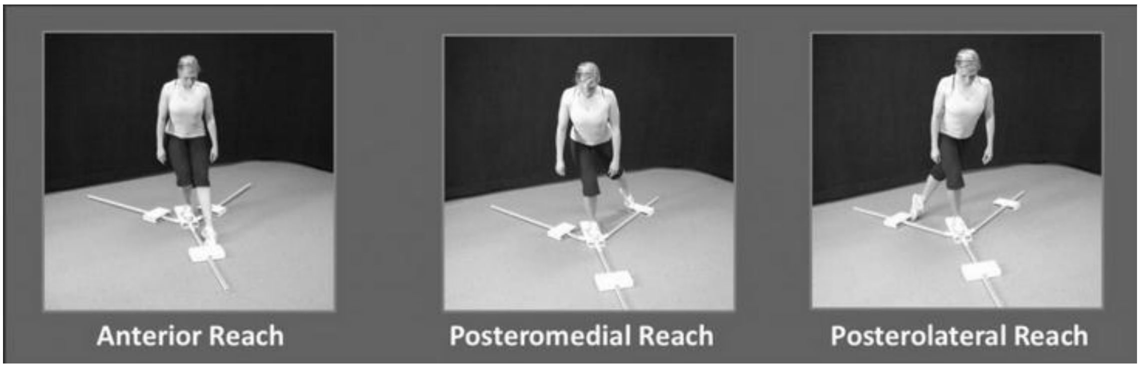

Figure 6 Y-Balance Test (Plisky et al, 2009)

Butler et al (2012) describe dynamic balance as an individual's ability to control their centre of mass during movement. It is a key component in many sporting activities and in particular with football inferior balance as well as superior balance is required for kicking (Butler et al, 2012; Lees ad Nolan, 1998). As well as this, dynamic balance is needed with most football skills including landing, jumping, changing directions, tackling, throwing a ball into play and sprinting (Butler et al, 2012; Lees ad Nolan, 1998). Assessing dynamic balance in sport has been proven to be beneficial as an increase risk of injury, in particular ankle and knee sprains, have been reported in athletes with poor dynamic balance (Dallinga et al, 2012). Specifically at the knee, literature has recognised an athlete with poor balance and neuromuscular control is more likely to sustain a non-contact ACL injury (Dallinga et al, 2012; Alentorn-Geli et al, 2009; Gioftsidou and Malliou, 2006). This is highly relevant to football as epidemiological studies have reported up to 19% of all injuries are ankle sprains and 3.6% are ACL injuries which are reported to be the most costly of all football injuries and lead to the most amount of time lost from football (Alentorn-Geli et al, 2009; Woods et al 2002; Heidt et al, 2000) Acknowledging that poor balance can increase injury risk, the Y-balance test was designed to assess dynamic balance in a simpler way to the Star Excursion Balance Test (Butler et al, 2012; Gorman, Butler, Rauh, Kiesel, and Plisky, 2012; Junge and Dvorak, 2007; Junge et al, 2002; Plisky, Rauh, Kaminski and Underwood, 2006) It only assesses 3 reach positions versus eight reach positions used in the star excursion balance test as research indicated that only 3 reach movements were necessary to predict injury and identify asymmetries (Plisky et al, 2009). The instrument was also designed to improve repeatability of dynamic balance as this was a common problem reported in the literature (Butler et al, 2012; Plisky et al, 2009).

Plisky et al (2009) examined the reliability of the Y-balance test in 15 healthy male college level football players. Two experienced Physiotherapists independently rated the scores on the Y-balance test. One of the Physiotherapists also repeated the procedure again 20 minutes later to establish intra-rater reliability. Plisky et al (2009) reported excellent inter-rater reliability in all reach positions and composite scores (ICC=0.97-1.0). Plisky et al (2009) also reported good intra-rater reliability with all reach positions and composite scores (ICC=0.85-0.89). These results indicate that the reliability appears to be greater than that reported with the star excursion balance test which has a great variation in results (inter-rater reliability ICC=0.35-0.93; intra-rater reliability ICC=0.67-0.97). However, it must be noted that Plisky et al's (2009) study have a number of limitations. Plisky et al (2009) only scored 15 subjects; they used two experienced Physiotherapists for inter-rater reliability and only one Physiotherapist for intra-rater reliability.

Although normative values exist for the star excursion balance test, to date there are no known normative values on the Y-balance test making it difficult to transfer to different populations and to establish which scores may place an athlete at risk of injury (Butler et al, 2012). Considering the Y-balance test is a modified version of the Star Excursion Balance Test, initially researchers believed normative values from the same direction of reach from the star excursion balance test could be used for the Y-balance test. However, Coughlan et al (2012) compared performance on the star excursion balance test and Y-balance test and found significant difference is the anterior reach direction for the right (p=.0002) and left leg (p=.003). Although no significant differences were found with the posterolateral or posteromedial directions, Coughlan et al (2012) concluded that the values between tests were not transferable. Therefore more studies on the Y-balance test to establish normative values and injury prediction risk need to be conducted.

8.4.2 Modified Thomas Test

Throughout the study the modified Thomas test has shown the most surprising results. In *Phase 1A* the modified Thomas test was selected by 100% of Physiotherapists in Round 1 and Round 2. In *Phase 2* it had an overall agreement rating of 2.38, the second highest agreement level in this threshold band. The results are surprising as the modified Thomas test is a plinth-based muscle length test which assesses the excursion of the hip flexors (Gabbe et al, 2004; Gore, 2000; Harvey, 1998). Therefore it is not classified as a functional test and raises questions as to why participants in both phases felt it should be included in a Functional Movement Screening Tool for Football.

The modified Thomas test was designed to evaluate hip flexor flexibility, predominantly of iliopsoas but also includes components of the quadriceps, and tensor fascia lata (TFL)/iliotibial band (ITB) (Gabbe et al, 2004; Gore, 2000; Harvey, 1998). To begin the test the athlete sits on the edge of the plinth and then rolls back to lying on the plinth with both knees being held into the chest to ensure the pelvis is posteriorly rotated and that the lumbar spine is flat (Gabbe et al, 2004; Gore, 2000; Harvey, 1998). Using the arms, one leg is held to the chest in maximal flexion while the test leg is lowered towards the floor and then relaxed allowing gravity to take the test leg into the passive end point (Gabbe et al, 2004; Gore, 2000; Harvey, 1998). At this end range position three angles can be measured to determine the length of the iliopsoas, quadriceps and TLF/ITB muscles (Gore, 2000; Harvey, 1998). Most commonly a goniometer is used to record the angles of hip flexion, hip abduction and knee flexion (Gabbe et al, 2004; Gore, 2000; Harvey, 1998).

In football, the hip flexors play an important role in kicking of the football and in sprinting (Shan and Westerhoff, 2005; Dorge, Andersen, Sorensen, Simonsen, Aagard, Dyhre-Poulsen and Klausen, 1999; Lees and Nolan, 1998) Although all hip flexors are involved in kicking, in particular, the rectus femoris is eccentrically lengthened as the hip extends and the knee flexes in order to prepare for the kick (Garcia, Durkop, Seijas, Ares and Cugat, 2012; Shan and Westerhoff, 2005). Directly following this, the muscle must then rapidly concentrically contract to bring the leg forward for the kick (Garcia et al, 2012; Shan and Westerhoff, 2005). However, the modified Thomas test does not specifically assess rectus femoris length unless the knee angle is also measured (Peeler and Anderson, 2008; Gabbe et al, 2004; Gore, 2000; Harvey, 1998). This is frequently referred to as the Kendall test and its reliability as a measure of rectus femoris length has been reported as poor when scored as pass/fail (intra-rater ẋ=0.40; inter-rater ẋ=0.33) (Peeler and Anderson, 2008). Also, interestingly the Kendall test was excluded in *Phase 1* of the study. Therefore it can only be presumed the modified Thomas test is being used as a measure of hip flexor flexibility and its implications in football screening are in turn limited.

Dennis, Finch, Elliot and Farhart (2008) investigated the reliability of musculoskeletal screening tests. In high performance cricketers they used Physiotherapists to evaluate a number of musculoskeletal tests including the modified Thomas test at the hip. Dennis et al (2008) examined the modified Thomas test in both hip extension and hip abduction and reported poor inter-observer reliability, ICC=0.27 and ICC=0.29 respectively. Intra-observer reliability was substantially better with the modified Thomas test in extension having an ICC=0.97 and the modified Thomas test in hip abduction ICC=0.83. Dennis et al (2008) only based their results on single measurements as opposed to a mean of multiple scores. The results of Dennis et al's (2008) study report intra-observer scores to be similar to previous research but the inter-observer scores were lower than reported in other studies (Gabbe et al, 2004; Harvey 1998).

8.4.3 Vertical Jump Test

The vertical jump test has been consistently included in each phase of this study. It was selected by 87.5% of participants in *Phase 1A* and it received an overall rating average of 2.46 showing agreement with it being included in the Functional Movement Screening Tool for Football. Most commonly the vertical jump test is used to assess an athlete's linear jump height which is an important skill in football, in particular for heading the ball (Paoli, Bianco, Palma and Marcolin, 2012; Sannicandro et al, 2012; Turner, Walker, Stembridge, Coneyworth, Reed, Birdsey, Barter and Moody, 2011; Reiman and Manske, 2009; Chu, 1996; Semenick, 1994). Kristensen, Andersen and Sorensen (2004) reported that on average a player heads the ball over 6 times per match and more than 20% of goals in the 2002 world cup were scored from headers. Therefore the skill of heading the ball has the potential to influence the outcome of a match (Paoli et al, 2012; Kristensen et al, 2004). It has been used in a number of studies as a part of a pre-participation screening examination or performance evaluation, including the F-MARC football test battery (Gore, 2000; Rosch et al 2000). More recently, the vertical jump test has been used to assess lower limb functional asymmetries (Sannicandro et al, 2012; Fousekis, Tsepis and Vagenas, 2010; Impellizzeri, Rampinini, Maffiulletti and Marcora, 2007). As football involves asymmetrical activities such as running, cutting, side-stepping, acceleration, deceleration, jumping and landing, measuring functional asymmetries may identify players who are potentially at risk of injury (Sannicandro et al, 2012; Gstottner, Neher, Scholtz, Millonig, Lembert and Rachner, 2009).

When assessing the vertical jump, there are many factors to consider. These may include the type of jump and the arm positioning during the testing procedure. Commonly testers will choose to either use a squat jump (SJ) or countermovement jump (CMJ) with or without arm swing (Paoli et al, 2012; Sannicandro et al, 2012; Reiman and Manske, 2009). According to Paoli et al (2012) the mechanics of heading the football are most similar to the CMJ with arm swing. Sannicandro et al (2012) agree with the use of the CMJ in football for functional assessment and preventative screening. Therefore it would seem appropriate to use the CMJ with arm swing for vertical jump height assessment in football.

Another factor to consider is the testing procedure as there are a number of devices that may be used to measure the vertical jump. A basic way of measuring the vertical jump is by using a chalk mark on the wall (Gore, 2000). At the start of the test, the athlete reaches up and makes a mark on the wall. The athlete then performs the vertical jump and makes a further mark on the wall as high as they possibly can. The tester then measures the distance between the two marks and the measurement is recorded (Gore, 2000). Although this measurement has its limitation, it is a cheap method as it only requires a piece of chalk and a tape measure and can be used in football at all playing levels (Gore, 2000). Another method commonly used is a Vertec jump measure. The Vertec consists of a vertical pole with horizontal vanes attached to the pole. At the start of the test the horizontal vanes are aligned in the same direction with the lowest vane adjusted to be at the tip of the athlete's extended arm. As the athlete jumps, they use their hand to push away the highest vane they can reach and again the difference between the standing height and jump height are recorded (Reiman and Manske, 2009; Gore, 2000; Chu, 1996; Semenick, 1994).

A jump mat with a belt may also be used to measure vertical jump height. This requires the athlete to stand on a rubber mat with a tape feeder attached to the bottom of the mat and to belt that goes around the athletes waist (Buckthorpe, Morris and Folland, 2012). The tape is set to zero at the start of the jump then the tape feeds until the apex of the jump is reached and a value representing the jump height is available from the length of the tape (Buckthorpe et al, 2012). A contact mat is another device that may be used to record vertical jump height. The contact mat is connected to a digital timing device which is used to record the time from which the athlete leaves the mat at the start of the jump until contact with the mat on landing (Buckthorpe et al, 2012). Jump height is calculated through a mathematical equation involving flight time and height of body centre of mass resulting in a jump height value being provided (Buckthorpe et al, 2012).

Finally more advanced technology such as laboratory or portable force plates may be used to record vertical jump height. This method is seen as advantageous as vertical jump height can be measured as well as concentric and eccentric peak forces and ground reaction forces (Sannicandro et al, 2012; Fousekis, et al, 2010; Impellizzeri et al, 2007). Therefore this method may allow for lower limb functional asymmetries to be detected which may in turn place a player at risk for injury (Sannicandro et al, 2012; Gstottner et al, 2009). However, it is unlikely that most football clubs will have access to this technology as the data analysis equipment is rather expensive (Turner et al, 2011).

From the literature, it appears more evidence is available to support including the vertical jump test as a performance marker or a baseline measure for return to sport following an injury as opposed to an injury screening test (Turner et al, 2011; Reiman and Manske, 2009; Gore, 2000; Rosch et al, 2000; Chu, 1996; Semenick, 1994). Vertical jumps are also a part of the FIFA 11+ preventative exercise programme (FIFA, 2009). Although recent literature has shown that functional asymmetries may be identified though a vertical jump test, this is only though measuring the vertical jump utilising force plates (laboratory or portable) (Sannicandro et al, 2012; Fousekis, et al, 2010; Impellizzeri et al, 2007). Although the in-line lunge and single-leg squat do not replace the vertical jump assessment on a force plate, they are also designed to assess functional asymmetry and could detect asymmetries in the absence of expensive equipment (Clark and Lucett, 2010; Reiman and Manske, 2009; Cook et al, 2006a, Liebenson, 2002).

Buckthorpe et al (2011) investigated the reliability of 4 field based vertical jump measurement devices (Vertec, contact mat, jump belt and portable force plates) in comparison to laboratory force plates. A total of 40 healthy adults (31 males, 9 females) performed 3 CMJs with arm swing on each device in a counterbalanced randomisation method. A rest of 60 seconds was given between jumps and the highest measure on each device was recorded. Buckthorpe et al (2011) reported jump heights recorded on the portable force plates and with the jump belt to be within 1cm of the height recorded on the laboratory force plates. The Vertec reported jump height to be 2.4cm lower than the laboratory force plates and the contact mat 11.6cm lower. As laboratory force plates are not available at all levels of football and only a small percentage of footballers play at an elite level (Engebretsen et al, 2008) using laboratory force plates would not represent a functional screening tool that is easy to administer in the field (Turner et al, 2011). Therefore one of the alternative methods for measuring vertical jump such as the jump belt or portable force plates are recommended as they have shown a significant positive correlations with laboratory measurements.

8.4.4 Internal & External Rotators of the Hip Assessment

The internal rotators of the hip assessment (2.42) and the external rotators of the hip assessment (2.54) were both selected by participants in *Phase 1A* and *Phase 2* for inclusion in the Functional Screening Tool for Football. However, in *Phase 1A* both tests only received 75% selection just making the minimum threshold criterion for inclusion. The internal rotators of the hip assessment surprisingly received a higher agreement rating even though 22 participants responded with a neutral or positive agreement response for both tests (Table 10). The difference in rating scores comes from the fact that more participants strongly agreed with the Internal Rotators of Hip Assessment being included in the tool (Table 10).

According to Bullock-Saxton and Bullock (1994) the internal rotators of the hip assessment evaluates the length of the internal hip rotators; tensor fascia latae, gluteus medius and minimus. This is assessed by having the athlete lying prone on a hard surface. The test leg is then passively moved to achieve 90 degrees of knee flexion. The movement is measured by using a goniometer with the stationary arm parallel to the testing surface and the moveable arm parallel to the test leg. The tester places one hand on the opposite posterior superior iliac spine then passively internally rotates the test leg until rotation of the pelvis is noted; this angle is the recorded measure (Bullock-Saxton and Bullock, 1994). The external rotators of the hip assessment evaluate the flexibility of the external rotators; piriformis, gamellus superior and inferior, obturator internus and externus and quadratus femoris (Bullock-Saxton and Bullock, 1994). This is assessed in the same format as the internal rotators of the hip assessment, however this time the test leg is passively externally rotated until rotation at the opposite posterior superior iliac spine is felt (Bullock-Saxton and Bullock, 1994). Both tests are reported to be positive if range of movement is asymmetrical (Reiman and Manske, 2009; Bullock-Saxton and Bullock; 1994). Interestingly, Gore (2000) describe the same test procedure as Bullock and Saxton (1994) but state the test is used to assess the range of movement of hip internal and external rotation instead of muscle length. As a measure for range of movement, research has shown a link between a reduction in internal rotation and increase injury risk although specific injuries were not identified (Dallinga et al, 2012).

Dennis et al (2008) reported on the inter and intra-observer reliability of assessing hip internal and external rotation in cricketers but as seen in Gore (2000) they referred to the test as examining range of hip motion, not muscle length. Both test showed good intra-observer reliability; internal rotation (ICC=0.94) and external rotation (ICC=0.88). Interestingly the results varied for inter-observer reliability with internal rotation (ICC=0.30) and external rotation (ICC=0.66). These results were substantially lower than the results reported by Reiman and Manske (2009) who found an ICC=0.99 with external rotators of the hip assessment and ICC=0.98 with internal rotators of the hip assessment inter-rater reliability. Dennis et al (2008) do not clearly state their testing procedure which may have contributed to the lower ICC values.

8.4.5 Adductor/Groin Flexibility Test

The adductor/groin flexibility test was selected by 87.5% of participants in *Phase 1A* and had an overall rating average of 2.69 in *Phase 2*. The adductor/groin flexibility test is a muscle length test measuring the length and flexibility of the hip adductors (Reiman and Manske, 2009; Peterson-Kendall, McCreary, Geise-Provance, McIntyre-Rodgers and Romani, 2005; Gore, 2000). In football, the adductor muscles are used in a number of different skills. They are involved in kicking with the inside of the foot, tackling, lateral lunging for a ball and during dribbling (Shan and Westerhoff, 2005; Lees and Nolan, 1998).

Unlike other muscle length tests, there does not appear to be one standardised way of measuring adductor/groin flexibility. This was apparent in *Phase 1B* of the study where participants struggled to agree on the most appropriate measuring for recording adductor muscle length. One proposed method of assessing adductor length involves the athlete sitting on the floor with their knees bent, their feet flat on the floor and legs together. The athlete is then instructed to let their knees drop sideways as far as possible keeping the feet together. The soles of the feet should be together and facing each other. The athlete is then asked to hold on to their feet with both hands, and pull the ankles as close to the body as possible. The distance from the heels to the groin is then recorded using a tape measure. Although measurements are given relating to poor to excellent flexibility, this information is not backed up by scientific evidence. It was found on a couple of sports science testing websites (www.topendsports.com/ www.bianmac.co.uk). Peterson-Kendall et al (2005) describe a unilateral plinth based test for assessing adductor length. The athlete starts by lying supine with legs straight out on the testing surface. The moving arm of the goniometer is aligned to the long axis of the femur and the stationary arm is parallel to a line between the anterior superior iliac spines. The testing leg is moved away from the midline until femoral rotation occurs; indicating the end of the adductor flexibility and this angle is recorded (Football Medicine Manual, 2009; Peterson-Kendall et al, 2005). A more functional variation, the sideways leg split has been used in the F-MARC football test battery to assess adductor muscle length (Rosch et al, 2000). This requires the athlete to stand on a smooth testing surface with the upper body supported through the hands on a chair or bed. The athlete is then instructed to slide both legs outward while maintaining the feet in an outward position. When the athlete can no longer slide the legs apart, the distance from the pubic symphysis to the ground is measured to the nearest 0.5cm (Rosch et al, 2000). Very little data exists on normative data for the above mentioned muscle length tests making it difficult to establish which method of measurement has the best reported reliability and validity in football.

Assessing the flexibility, strength and function of the hip adductors is believed to be important in football as 11-23% of injuries are shown to affect the groin (Ekstrand et al, 2011; Hagglund et al, 2012; Hagglund et al, 2005; Walden et al, 2005; Hawkins and Fuller, 1999; Ekstrand and Gillquist, 1983). However, there is limited evidence that shows measuring isolated adductor muscle length are a valid predictor of adductor muscle strains in football (Dallinga et al, 2012). In fact, research has reported no relationship between reduced adductor length and increased risk of injury (Engebretsen et al, 2010b; Arnson et al, 2004; Witvrouw et al, 2003; Tyler, Nicholas, Campbell and McHugh, 2001) Considering the aim of this study was to establish which tests should be in a functional screening tool it is interesting that an isolated adductor muscle length test was selected over a side step or lateral lunge test which assess more dynamic flexibility of the adductor muscles (Reiman and Manske, 2009). However, both the side step and lateral lunge were eliminated in *Phase 1A*, Round 1.

8.4.6 Gastrocnemius Test

The gastrocnemius test had an overall average rating score of 2.96 and was only just included in the Functional Screening Tool for Football as the score was below the 3.0 threshold criterion. This was similar to *Phase 1A* where the gastrocnemius test was selected by 75% of participants which was the minimum score for inclusion. This is not completely unexpected as the gastrocnemius test selected in this study, is a plinth-based muscle length test and is not viewed as a functional test. However, it is known that calf injuries represent up to 13% of muscle injuries in football (Hagglund et al, 2012; Ekstrand et al, 2011). Therefore it is important to be able to assess if someone is at risk of a gastrocnemius muscle injury. These results could reflect the fact that Physiotherapists acknowledge the muscle is commonly injured in football and should be assessed; it's just unclear if this should be done through functional movements or isolated muscle length test.

The gastrocnemius test is used to establish the flexibility, length and excursion of the two-joint gastrocnemius muscle (Reiman and Manske, 2009; Peterson-Kendall et al, 2005; Berryman Reese and Bandy, 2002). It involves the athlete lying supine with both the hip and knee extended to a flat position on the plinth. Whilst maintaining knee extension, the athlete then actively dorsiflexes the ankle and the range of movement is recorded using the lateral malleolus as the axis, the head of fibula as the stationary arm and the moving arm parallel to the fifth metatarsal (Reiman and Manske, 2009; Peterson-Kendall et al, 2005; Berryman Reese and Bandy, 2002). Peterson-Kendall et al (2005) state up to 20 degrees of dorsiflexion should be achievable, but Reiman and Manske (2009) report no known normative data for this test.

Although normative data may not be available for the plinth based gastrocnemius test, Wang, Whitney, Burdett and Janosky (1993) reviewed the intra-tester reliability of the gastrocnemius test and reported good correlation in 10 long distance runners (ICC=0.98). Although other studies reported on the inter-rater and intra-rater reliability of gastrocnemius muscle flexibility, a weight-bearing lunge test was used therefore the data is not transferable (Dennis et al, 2008; Witvrouw et al, 2003)

8.5 Tests With an Overall Average Rating Above 3.0

Only two tests had an average rating above 3.0 showing that the majority of participants disagreed with them being included in the Functional Movement Screening Tool for Football. The two tests excluded were the piriformis test (3.0) and soleus test (3.04).

The exclusion of these two tests is not particularly surprising. When reviewing the injury epidemiology literature in football, piriformis muscle injuries were not commonly seen in football. In fact no studies specifically listed piriformis injuries in their epidemiological reviews of football injuries and where reference was made this was in relation to the presence piriformis syndrome not piriformis strains (Woods et al, 2002). The piriformis muscle length test is not well documented in the literature with variations in testing procedures. Peterson-Kendall et al (2005) and Kroon and Kruchowsky (2006) describe the test procedure with the patient in supine on a plinth while the tester passively flexes the athletes hip to 90 degrees, then adding in adduction and internal rotation to the point of limitation. Fishman, Dombi, Michaelsen, Ringel, Rozbruch, Rosner and Weber (2002) describe similar movement patterns but with the start position of the athlete in side lying and the testing leg up. However, with both of these procedures, the degree of hip adduction and internal rotation are not described and are open to interpretation of the tester. The piriformis test narrowly made it into Phase 2 of the study as only 75% of participants in *Phase 1A* selected the tool, meaning it just met the minimum threshold for inclusion in the first phase. As well as this, the piriformis test was one of the tests that sparked a debate between Physiotherapists in *Phase 1B*. When it came to discussing operational definitions for each test, Physiotherapists began questioning as to why this test had been included (Appendix 11). The group appeared to be having an internal debate on the relevance of the test in football screening. This debate agrees with the participants in *Phase 2* as it was at the 3.0 threshold and therefore not included in the Functional Movement Screening Tool Specific for Football.

Although calf injuries are seen in football, literature has shown gastrocnemius is more frequently injured than the soleus muscle (Dixon, 2009; Koulouris, Ting, Jhamb, Connell and Kavanagh, 2007). In *Phase 1B* of this study, the soleus tests also caused internal debate amongst participants (Appendix 11). Some Physiotherapists questioned the relevance of measuring muscle length on a plinth in a non-functional method. A dorsiflexion lunge test was suggested but this test had been eliminated by participants in *Phase 1A* as it was only selected by 62.5% of participants which was below the 75% minimum threshold level for inclusion. There seemed to be conflict in the relevance of including this test in the football screening tool. This is again reflected in *Phase 2* as its overall average rating was 3.04 meaning the majority of participants did not agree with it being included in the Functional Movement Screening Tool Specific for Football.

8.6 Difference in Relation to Football League Level of Employment

When reviewing the results broken down to the level of employment in the football leagues a few variations in agreement for inclusion can be noted. As the football leagues are hierarchical in nature, results will be briefly discussed by the Physiotherapists' league of employment to allow for comparisons across the leagues.

Championship Physiotherapists had been qualified the longest with 6 of the 9 Physiotherapists reporting being qualified for 11-15 years. Only 1 other Physiotherapist reported being qualified for 11-15 years and this was in League One. Interestingly 2 Physiotherapists (1 League One, 1 Other Leagues) reported working in football for 16-20 years despite no Physiotherapists reporting being qualified for more than 15 years. This raises questions as to whether they previously occupied a different role in sport such as a Sports Therapist or Sports Scientist before qualifying as a Physiotherapist. In future, the question needs to state "how many years have you worked as a Chartered Physiotherapist in football" to avoid discrepancies in the data.

With regards to each individual test agreement, differences can be observed in relation to the different leagues of employment. This was most evident on the vertical jump test and modified Thomas test. The vertical jump test showed the largest results range (1.00-5.00) However, the 1.00 rating came from a single Conference League Physiotherapist and the 5.00 rating from a single League Two Physiotherapist (Table 24). The average from the groups ranged from 2.13-2.67 showing a stronger level of agreement from the overall group. The modified Thomas test had the second largest results range (1.63-5.00). Table 20 shows the highest agreement score came from the average of the 8 Physiotherapists in League One (1.63) and the lowest score from the single League Two Physiotherapist (5.00).

The strongest agreement was observed for the single-leg squat (1.0-1.71) which is no surprise as it had the highest overall average rating score (1.46). All participants either strongly agreed or agreed (1.00-1.71) with its inclusion in the Functional Movement Screening Tool for Football with higher proportion showing strong agreement. The highest number of Physiotherapists only showing agreement with the inclusion of this test was Physiotherapist who reported working in Other Leagues and the overall rating average for this group was 1.71 which is still below the 2.0 threshold.

8.7 Testing Overlap and Redundancy

Developing a functional screening tool that is sport specific is important in order to reduce the risk of injury (Schneiders et al, 2011; Requena et al, 2009; Cook, 2003; Rosch et al 2000). However, it is also important to effectively gain the necessary information in a timely fashion (Cone, 2012; Blanch, 2005). With this in mind, balance needs to be achieved by limiting the amount of redundant information collected between different tests (Cone, 2012).

Within the 10 tests selected to be included in the Functional Movement Screening Tool for Football, some overlap of structures tested does exist. The aim of this study was to develop a functional movement screening tool that was specific for football. However, 5 muscle length tests have been included by participants from both phases in this study. As dynamic muscle length is assessed during some of the functional movements, it is questionable if there is a need to further assess isolated length of specific muscles. For instance the overhead squat and single-leg squat will assess the dynamic length of the gastrocnemius muscle and replicates movements occurring in football match (Cook et al, 2006a; Clark and Lucett, 2010; Cook, 2003). Therefore it is debatable if there is a need to measure the gastrocnemius muscle length in a supine position on a plinth as well. It is even more questionable as football literature has only shown a weak correlation between reduced muscle flexibility and an increase risk of injury (Engebretsen et al, 2010b; Dallinga et al, 2009; Arnson et al, 2004; Witvrouw et al, 2003).

8.8 Functional Movement Screening in Football vs Screening in Football

It could be argued that the tool developed in this study is more representative of a screening tool in football instead of a Functional Movement Screening Tool for Football. Of the 10 tests selected for inclusion, only 3 of the tests are reported to be functional movements; single-leg squat, deep squat and in-line lunge. The remaining 7 tests included 1 balance test (Y-balance test), 1 performance test (vertical jump) and 5 muscle length tests (the modified Thomas test, internal and external rotators of the hip assessment, adductor/groin flexibility and the gastrocnemius test). As currently no standardised screening tool exists for football screening, the responses in this study could reflect a need for a generalised screening tool, not specifically a functional movement screening tool. Irrespective of this, the tool has been developed by Physiotherapists who work in football. Therefore the developed tool has included tests that this group believe are needed for football.

8.9 Limitations of ***Phase 2***

In trying to determine which tests should be in a Functional Movement Screening Tool for Football, many challenges were encountered. One of the main difficulties was access to potential participants, Physiotherapists working in football. Numerous recruitment strategies were utilised as contacting and communicating with football Physiotherapists was not easy. This could potentially impact on information sharing as trying to distribute the screening tool in the field for use may be difficult. In particular, access to Physiotherapists in leagues lower than League One may pose the greatest challenge as only a limited number of Physiotherapists below League One participated in this study.

When working in professional football, maintaining confidentiality and anonymity is vital. As it is important to uphold a competitive edge, information sharing is kept to a minimum within professional football. This means barriers are encountered and methodological choices are limited for this particular group (Drust, 2013). In order to maintain anonymity, challenges in data collection arose. To maximise recruitment, participants were not required to provide a contact name, number or email address. Therefore all correspondence was always sent to all potential participants, even if they had already completed the online survey. Without having contact names, it is also impossible to ensure those who completed the online questionnaire were Chartered Physiotherapists. This was of particular concern when the twitter methodology was employed. Once a statement has been posted on twitter, it is not possible to control who then re-tweets the post or who accesses the study information. This was considered before the twitter post was placed online and therefore it was decided the terms “UK Football Physios” would be placed at the start of the tweet to help attract the desired population. The inclusion criteria were also placed on the study summary that was linked to the twitter page as well as on the full study information sheet. Although this cannot guarantee only UK Football Physiotherapists completed the questionnaire, it was stated as explicitly possible.

Initially this study aimed to not only establish which test should be included in a Functional Screening Tool for Football but to also establish operational definitions and correct performance markers on each test. However, the study aims were changed as Physiotherapists were unable to agree on test definitions and began to question the tests that had been included by the consensus panel. Therefore operational definitions and performance markers have still not been established for each test. This could also have influenced the results in the revised *Phase 2*. With each test, Physiotherapists were encouraged to click on the test name to view the operational definition of each test. The initial online survey was divided into sections and were labelled in a specific test category (refer to pg 38). In *Phase 2,* the 12 tests were all listed together and were not in separate categories. If a Physiotherapist felt they were familiar with the test, they may not have clicked on the test definition and may have interpreted the test differently. As the literature has shown, with certain tests, different testing protocols may exist. For example, with the gastrocnemius test, the Physiotherapist may have believed this would be measured as a functional lunge test as opposed to non-weight bearing on a plinth. This may also be true for a Physiotherapist who may have interpreted the internal and external rotators of the hip assessment to measure range of motion instead of muscle length. Although there is a possibility for misinterpretation, it was outlined to the Physiotherapists that a definition for each test was available.

Different types of likert-scales are commonly used in questionnaires. In particular, a forced likert scale may be used when the researcher wants to force an answer and does not want respondents to remain neutral. In *Phase 2*, a number of respondents chose the middle choice which was neither agree nor disagree. This meant a decision on whether or not the test should be included into the final tool was not made. It could be argued that a forced scale could have been used to avoid this situation (Antcliff et al, 2013; Harland and Drew, 2013; Chau et al, 2012; Thomas et al, 2011). However, in this study it proved quite interesting that some respondents could not make a decision. It would be expected that autonomous practitioners should be able to offer an opinion on which tests they feel should be included in a Functional Movement Screening Tool for Football. The fact that they could not make a decision calls into question if Physiotherapists working in football are used to going along with general consensus, past knowledge and are not able to offer an independent opinion. It also shows there are a number of Physiotherapists who are still unsure which test should be in a Functional Movement Screening Tool for Football. This further highlights and confirms the challenges in establishing appropriate tests for screening in football.

9.0 CHAPTER NINE CLINICAL IMPLICATIONS

Football is the most popular sport in the world and is played by people of all ages, genders, ethnicities and abilities (Ekstrand et al, 2011; Emery et al, 2005). World-wide there are approximately 240-265 million amateur players and 200,000 professional players (FIFA, 2013; Emery et al, 2005; Junge et al, 2002). As with any sport, football players may be injured during a match or training (Ekstrand et al, 2011; Emery et al, 2005; Junge et al 2002). Although some of these injuries may come from un-modifiable incidences such as player contact, some injuries may be prevented through implementation of screening tools which serve to identify players who are potentially at risk for an injury (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). Screening may be conducted by Doctors, Physiotherapists, Sports Therapists, Coaches and Strength and Conditioning Practitioners (Mottram and Comerford, 2007; Blanch, 2005).

In the UK, professional football clubs are required to employ a Chartered Physiotherapist (FA, 2013). Preventing injuries is an important part of the Physiotherapists duties in football (Mottram and Comerford, 2007; Blanch, 2005). It has been shown that by identifying potential injury risk factors, an opportunity may arise to address or modify these factors therefore lessening a player's injury risk (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). However, in football a standardised widely used screening tool does not exist. The most recognised test battery used in football is the F-MARC performance evaluation which although includes screening tests, its purpose is to asses football skills and functional performance, not specifically injury prediction (Rosch et al, 2000). Therefore this study used Physiotherapists working in football to establish which tests should be used to screen functional movements which could potentially identify modifiable injury risk factors. This study specifically focussed on functional screening tests as functional tests are important in replicating sporting movements (Schneiders et al, 2011; Requena et al, 2009; Cook et al, 2006a; Cook, 2006b, Cook, 2003; Rosch et al 2000).

The screening tool itself has some clinical limitations. Within the literature screening has various definitions and is performed for a number of different reasons. As a Physiotherapist, screening is most commonly performed in order to identify athletes who are potentially at risk of injury (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). As well as this, screening may be performed in order to establish baseline measures for return to sport should a player sustain an injury (Schneiders et al, 2011; Blanch, 2005; Rosch et al, 2000). In recent times, the focus of screening has shifted to address functional movements that replicate movements that are required during dynamic activity (Schneiders et al, 2011; Reiman and Manske, 2009; Requena et al, 2009; Cook et al, 2006a; Rosch et al 2000). Further to that, studies have now begun to look at functional tests that are related to specific sports and the movements required in the designated sport (Frohm et al, 2011; Requena et al, 2009; Rosch et al 2000). As this type of screening is in early stages of development, there is still uncertainty of which tests best suit each specific sport. This study has actually shown that some of the tests included in the functional movement screening tool for football have been historically used as performance markers, not as injury prediction tools. In addition to this, not all tests that may be believed to replicate sporting performance have undergone reliability and validity testing for their ability to predict injury in sport and in particular in football. Of the individual tests that have been examined in terms of clinical reliability and validity, mixed results have been found. As well as this, the relevance to football is only implied with certain tests and there is a lack of evidence supporting the injury prediction relationship with each test. Therefore before being recommended for field use the developed tool would need to be subjected to reliability and validity testing in football.

The developed tool has included a combination of functional tests and muscle length tests. These results highlight that a clear definition of functional screening is needed. As a widely-accepted screening tool is not available in football, it is possible that the participants of this study chose tests which they felt were needed in a screening tool for injury prediction in football. Therefore it may not have mattered if the tests were considered functional. This would potentially explain why 5 plinth based muscle length tests were included in the developed functional movement screening tool for football. Interestingly 7 muscle length tests were also used in the F-MARC football performance evaluation although none of the tests were the same as the ones included in this study (Rosch et al, 2000).

Interestingly no specific muscle length tests for the hamstrings have been included in the functional movement screening tool. As discussed in Chapter Five, this was surprising as a significant number of hamstring injuries occur in football and 5 other muscle length test were included in the Functional Movement Screening Tool for Football (Ekstrand et al, 2011a; Ekstrand et al, 2011b; Ekstrand et al, 2009; Witvrouw et al, 2003; Hawkins et al, 2001; Inklaar, 1994; Ekstrand and Gillquist, 1983). Although hamstring performance may be indirectly assessed with the functional tests included in the screening tool, none of the tests included have been specifically linked to predicting hamstring injuries. Therefore the need to include an additional hamstring specific test may prove to be necessary. However, it must be noted that only a few studies have found that reduced muscle length is a predictor of hamstring injuries (Rolls and George, 2004; Witvrouw, 2003). Many studies have found no link and have suggested functional tests should be used (Arnason et al, 2004). For that reason, the tests selected may in time prove to be able to identify a potential risk of hamstring injuries.

More importantly standardised test procedures and scoring systems do not currently exist for all tests included in the functional screening tool for football. Therefore further work needs to be performed to establish test protocols and scoring systems for each test. Equipment required for each test also needs to be reviewed. If the tool is to be used in football at any level, expensive equipment is not suitable (Turner et al, 2011; Engebretsen et al, 2008). A possibility of developing alternative equipment protocols does exist but then the results are not comparable and normative values may not be gerenalisable to different levels of football. In particular, a decision not to recommend the use of force plate analysis with the vertical jump test has been made. Although force plates may help to identify functional asymmetries, the in-line lunge and single-leg squat which are simple to administer in the field, also address potential asymmetries and both movements replicate activities performed in football (Clark and Lucett, 2010; Reiman and Manske, 2009; Cook et al, 2006a; Liebenson, 2002).

Validating a tests ability to predict injury poses certain challenges. In order to prove a relationship exists between poor test performance and elevated injury risk, athletes would need to be evaluated performing a specific test and the results recorded with no intervention strategies being employed. If a player then sustains an injury, their performance on the test could then be examined. However, this is difficult in a sporting environment. If a Physiotherapist, Doctor, Sports Therapists or Strength and Conditioner identify poor performance on a test, as a professional there is a duty of care to correct performance in order to potentially prevent injury (Mottram & Comerford, 2007; Blanch, 2005). This means only a potential link with a test to predict injury is normally established. The link is often made by examining the components of a test and reviewing it against current literature to see if certain indicators on the test have been shown to pre-dispose to injury (Bishop, 2008).

Another way of identifying if the Functional Movement Screening Tool for Football is able to predict injury would be to compare injury rates from the previous season. Firstly this could be done by auditing players' injury history through medical records or a self-reported questionnaire. This could then be linked to a player's performance on the 10 screening tests established in this study. Secondly, overall injury rates could be compared over a further season. If the previous season's injury incidence and rates were recorded, these could be used for comparison. The athlete's would be screened using the Functional Movement Screening Tool for Football and any athlete who's performance on a test was considered less than ideal would be given corrective exercises. Injury rates following the implementation of the screening tool and corrective exercises could be compared to the previous year's data. Although it must be recognised that this will only show a possible relationship to injury risk and will not directly prove the validity of the functional screening tool as managerial changes, number of matches played and environmental conditions may also affect injury rates.

At this stage it is difficult to know if the developed tool will be able to predict injury in football. However, the panel of experts in *Phase 1A* and participants in *Phase 2* have selected and agreed on 10 tests which have been identified for the use of functional screening specifically for football. At the very least, the developed test battery could be used to establish baseline measures for comparison in football and more importantly baseline measures for individual players which could be used to return to football following injury.

10.0 CHAPTER TEN LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

10.1 Overall Study Limitations

Limitations of *Phase 1* and *Phase 2* have been discussed in previous chapters. However, a few overall study limitations need to be acknowledged as well. Importantly, there does not appear to be a consistent definition or clear understanding of what is involved in functional movement screening. At the start of the study, providing participants with a standardised definition may have resulted in different tests being included in the Functional Movement Screening Tool for Football. Although this is only a speculation, the fact that the developed tool included functional tests, performance tests and isolated muscle length tests strongly indicates there is un-certainty as to what is involved in functional screening.

As discussed in Chapter Five, test placement in *Phase 1A* may have influenced the exclusion of hamstring muscle length tests. As all hamstring specific muscle length tests were eliminated in *Phase 1A*, the participants in *Phase 2* were not able to offer their opinion if hamstring length tests should be included in the Functional Movement Screening Tool for Football. However, this could be argued for all tests excluded in *Phase 1A*.

Within football, barriers to data collection exist, especially at elite level (Drust & Green, 2013; Bishop, 2008). Traditionally football is closed to sharing and providing information to outside agencies (Drust & Green, 2013). This resulted in the use of a two round modified online Delphi technique to gain consensus on which tests should be included in a Functional Movement Screening Tool for Football. Even though a consensus panel that met in person may have generated important discussions around functional screening in football, the logistics and the reality of this happening posed many challenges. This study recruited 14 Physiotherapists working in Premiership football in *Phase 1A* who were able to share their views anonymously. Although this means conversations may not have developed, a substantial number of participants were accessed, meaning views from a larger group of people were accessed. To date, there are no other studies that have reported gaining information from such a large number of Physiotherapists working in elite football. As well as this, 26 Physiotherapists working in non-Premiership football also participated in this study, bringing the total number of participants to 40. This means views were gained from 40 Football Physiotherapist in total which is higher than found in other football and screening studies.

A pre-generated list of 84 tests was distributed to the participants for selection through an online survey process. The tests included on the first survey were identified through performing a literature search. A test was only included if a definition of the test procedure had been provided. As initially the project aimed to establish operational definitions for each test, it may not have been necessary to only include tests with defined procedural instructions.

Although there are strengths in performing independent research in football, some further limitations must be acknowledged. Football is a tightly regulated sport and changes are often driven and directed through implementation of new rules and regulations which usually come from the Football Association or the F-MARC board (Junge et al, 2009; Vamplew, 2007). Without endorsement from the Football Association, there may be some hesitation in the recognition and implementation of the tool in the football community (Junge et al, 2009; Vamplew, 2007). As well as this, endorsement from the Football Association or Football League may have encouraged participation and compliance. However, an argument could be made that by performing independent research, bias may have been reduced (Thomas et al, 2011) as participants are free to comment without feeling their responses are being monitored by the Football Association. It may have also reduced coercion as participants did not feel they had to participate which may have been the case if the project was endorsed the Football Association (Crust & Laurence, 2006; Olivier & Fishwick, 2003).

10.2 Recommendations for Future Research

As a result of the present study, 10 tests have been recommended for inclusion in a Functional Movement Screening Tool for Football. However, there are not standardised protocols for the correct performance on each of the chosen tests. Therefore further research on what constitutes correct performance and subsequently poor performance need to be established. Only then can a scoring system be developed for each of the tests. Literature has shown variable results for inter-rater and intra-rater reliability of the included tests. Standardising the performance protocol for each test may in turn improve its reliability. However, the inter-rater and intra-rater reliability will need to be examined once performance protocols and scoring systems have been developed.

Screening in sport is rarely gender specific. In most sports where screening tools exist, the same tests are used to assess male and female athletes. This may be due to the fact that the mechanics of the sport are primarily the same regardless of the gender. Therefore the injuries sustained are similar in nature, but the rates of each specific injury can vary for males and females, for example males and females may injure their ACL but females are 4-6 times more likely to damage this ligament than males (Schneiders et al, 2011; Alentorn-Geli et al, 2009; Dallinga et al, 2009). In light of this, some studies have found normative data and injury prediction threshold scores are often different between genders (Schneiders et al, 2011). Although *Phase 1* of the study used Physiotherapists working in men's professional football, the functional movement screening tool developed is not gender specific. Once a standardised scoring system is established, the functional screening tool would need to be tested on male and female football players to obtain normative data for gender comparison and to ascertain if injury prediction rates are equal for males and females.

Although some methodological limitations have been recognised, this study identified tests that were viewed as important in a Functional Movement Screening Tool for Football by two independent groups of Physiotherapists working in football. The included tests came from a range of resources and did not replicate any other screening tools used in football. In particular, this study found that Physiotherapists working in football did not believe that 5 of the tests from the well-known FMS tool should be used for screening in football. Therefore the study could be repeated in other sports to establish specific screening tools in a range of sports.

11.0 CHAPTER ELEVEN CONCLUSIONS

Football is the most popular sport world-wide (FIFA, 2013; Emery et al, 2005; Junge et al, 2002). As with any sport, playing football comes with a risk of injury (Ekstrand et al, 2011; Emery et al, 2005; Junge et al 2002). Therefore, preventing injuries is an important role of a Physiotherapist. Prevention of injuries helps to maintain an athlete's physical condition, improve individual and team performance and in turn reduce associated costs of injuries (Ekstrand et al, 2011; Bradley and Portas, 2007; Witvrouw et al, 2003). Prior to this study, there were no known standardised testing protocols that evaluated functional movement in football. This study has identified the limitations and restrictions in performing research in the football environment. It has also acknowledged the importance of identifying a functional movement screening tool that is specific to football and easy to use in a field environment.

The current study used a modified two round online Delphi consensus panel of experts to establish which test should be included in a Functional Movement Screening Tool for Football. The expert consensus panel was made up of Premiership Football Physiotherapists in *Phase 1*. The tests selected by the expert panel were then distributed to Physiotherapists working in any level of football to gain their level of agreement on each test being included in the Functional Movement Screening Tool for Football. In total, opinions of 40 Physiotherapists working in football from two independent groups were gained. To date, this is higher than in any other study in football of this nature.

This process successfully resulted in a total of 10 tests gaining agreement for inclusion in a Functional Movement Screening Tool for Football. Although not all of the 10 tests are normally considered functional tests, they were selected by a panel of experts and gained agreement by 2 sets of independent participant groups. It may be argued the developed tool is more representative of a screening tool for football as opposed to a functional movement screening tool. Regardless it has advanced current knowledge in football by establishing a standardised screening tool specific for football and developed by the Physiotherapists who work in the sport and carry out screening procedures. The following 10 tests were included:

- Single-leg Squat
- Deep Squat
- In-line Lunge
- Y-balance Test
- Modified Thomas Test
- Internal Rotators of the Hip Assessment
- Vertical Jump Test
- External Rotators of the Hip Assessment
- Adductor/Groin Flexibility Test
- Gastrocnemius Test.

The study has identified methods that help overcome traditional barriers in football allowing for important data collection. This included the use of a modified two round Delphi methodology to gain opinions from Premiership Football Physiotherapists who are often difficult to access and the introduction of twitter for participant recruitment. As well as for recruitment purposes, twitter may prove to be a valuable tool for disseminating information in the football community. At this stage the developed tool can be used to establish baseline measures for return to sport following injury. Once established definitions and scoring systems have been developed for each test, the screening tool in turn may be used to potentially predict injury in football.

Key Findings of this Study Include:

- Identification of successful methods for overcoming barriers in performing research in professional football
- Successful implementation of a modified two round online Delphi technique to gain responses from a group of Physiotherapists who are often difficult to access
- Twitter served as a vital tool for recruitment in *Phase 2* of this study and may prove to be a useful resource for disseminating knowledge to Football Physiotherapists
- Agreement from 2 independent groups of Physiotherapists on 10 tests to be included in a Functional Movement Screening Tool for Football
- Advancement of knowledge in football research

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Appendix 1- Test Definitions

Deep Squat

Purpose

The squat is a movement needed in most athletic events. It is the ready position and is required for most power movements involving the lower extremities. The deep squat is a test that challenges total body mechanics when performed properly. The deep squat is used to assess bilateral, symmetrical, functional mobility of the hips, knees, and ankles. The dowel held overhead assesses bilateral, symmetrical mobility of the shoulders as well as the thoracic spine.

Procedure

1. The individual assumes the starting position by placing his/her feet approximately shoulder width apart and the feet aligned in the sagittal plane.
2. The individual then adjusts their hands on the dowel to assume a 90-degree angle of the elbows with the dowel overhead.
3. Next, the dowel is pressed overhead with the shoulders flexed and abducted, and the elbows extended.
4. The individual is then instructed to descend slowly into a squat position. The squat position should be assumed with the heels on the floor, head and chest facing forward, and the dowel maximally pressed overhead.
5. As many as three repetitions may be performed.
6. If the criteria for a score of III is not achieved, the athlete is then asked to perform the test with a 2x6 block under their heels

Standing Long Jump

Purpose

To assess lower extremity functional strength, neuromuscular control and dynamic power.

Procedure

1. Position the client so that he or she is standing with bilateral feet a comfortable distance apart just behind the starting line
2. You can choose from various hand positions (hands on hips/behind the back, or free for use during the jump) but keep the hand placement consistent
3. Have the client perform a maximal jump along the testing surface
4. Allow the client to perform a countermovement prior to jumping
5. Instruct the client to hold the landing to allow the distance to be marked
6. Note that for the jump to qualify as a legitimate jump the client must land without losing balance, or falling or taking an additional step
7. Measure the distance from the starting line to the back of the heel closest to the starting line
8. Have the client perform 3 trials, with adequate rest for recovery between trials
9. Record the average of the 3 trials

Functional Reach Test

Purpose

To determine a client's functional ability to reach with the upper extremity while maintaining trunk stability.

Procedure

1. Instruct the client to reach as far as possible (shoulders at 90deg of flexion and elbows fully extended)
2. Use a yardstick mounted on the wall at the level of the acromion to measure reach distance
3. Measure reach distance as the displacement of the fingers between initial position and end position

Single Leg Squat (Small Knee Bend)

Purpose

To assess lower extremity functional strength, neuromuscular control and dynamic stability via a single leg.

Procedure

1. Have the client stand in single-leg stance on the leg to be assessed
2. Preferable ask the client to perform the test without shoes on so that you can monitor foot biomechanics
3. Instruct the client to keep the trunk and upper body as upright as possible during the squat
4. Instruct the client to place bilateral hand on hips
5. Instruct the client to squat down as far as possible toward the floor, bending at the hip, knee, and ankle as far as necessary

Triple Hop for Distance

Purpose

To assess the ability to produce power, speed, balance and single lower extremity control over a specified distance with specific emphasis on distance covered by the single lower extremity

Procedure

1. Following a warm-up position the client so that he or she is lined up directly behind the starting line, balancing on the lower extremity to be tested
2. Instruct the client to perform 3 consecutive maximal-distance hops on one foot in a straight line direction, that to stand on one leg and hop three times as far as possible with maximal effort
3. Chose the hand position you prefer (hand on the hips or behind back, or free to move) and instruct the client on that hand position
4. Perform the test 3 times and average the values of the distance covered

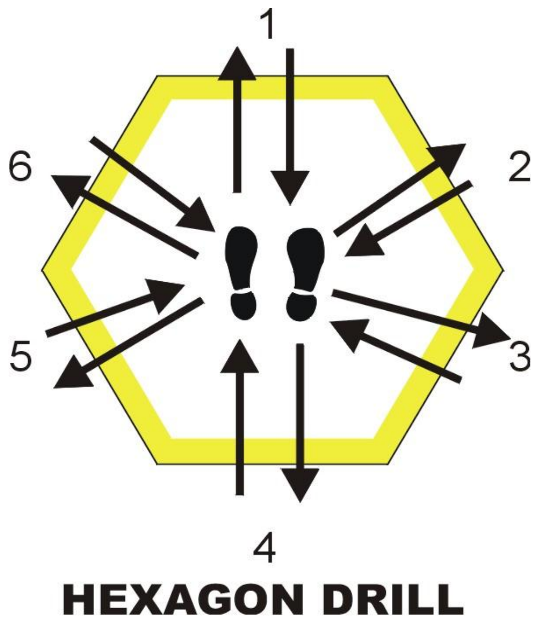
Hexagon Test (Bilateral Lower Extremity Jump)

Purpose

To assess the ability to produce power, speed, balance, agility and bilateral lower extremity control over a specified vertical and horizontal distance and over repetitions, with specific emphasis on speed in a repetitive up-and-down manner for bilateral lower extremities.

Procedure

1. Have the client start in the centre of the hexagon and face forward throughout the test.
2. To begin the test, ask the client to perform a double-leg jump over the line immediately in front of him or her and jump back to the centre.
3. Have the client work in a clockwise sequence until he or she has jumped over each of the six sides 3 times consecutively without stopping.
4. Have the client perform 3 trials, resting for 1-2 minutes after each of the first two.
5. Record the best time to the nearest tenth of a second (or you can choose to record an average of the 3 trials)
6. Note that disqualification results if the client lands on a line, loses balance or has to take a step.



Inline Lunge

Purpose

The test is aimed at placing the body in a position that will focus on the stresses incurred during rotational, decelerating and lateral-type movements. The test is used to assess hip mobility and stability, as well as ankle and knee stability.

Procedure

1. Measure the client's tibial length with a tape measure.
2. Have the client place one foot on the end of a 2x6 board.
3. Mark the distance of the client's tibial length on the 2x6 from the client's back toe
4. Place the dowel rod behind the client's back, touching the head, thoracic spine and sacrum.
5. Instruct the client to grasp the top of the dowel with the hand ipsilateral to the back of the foot.
6. Ask the client to take a step and place the front of the heel on the mark.
7. Ensure the client's feet are on the same line and pointing straight ahead throughout the assessment.
8. Have the client perform the lunge up to 3 times in a slow controlled manner.

Tandem Walking

Purpose

To assess balance.

Procedure

1. Instruct the client to stand with the feet straddling a straight line.
2. Ask the client to walk heel to toe along the straight line for approximately 10yd (9m).
3. Instruct the client to return to the starting position by walking backward.

Side-Step Test

Purpose

To assess balance by determining the distance the client can sidestep. Sidestepping requires considerable balance and coordination.

Procedure

1. Instruct the client to stand in the starting position with legs and feet together on the starting line; in principle, the feet are in contact in this position.

2. Ask the client to sidestep 5 steps attempting to make the steps as wide as possible.
3. Instruct the client not to support the body with the arms and not to jump.

Trunk Stability Push Up

Purpose

To assess the ability to stabilise the spine in an anterior and posterior plane during a closed-chain upper body movement. This test is used to assess trunk stability in the sagittal plane while a symmetrical upper extremity motion is performed.

Procedure

1. Position the client so that he or she is prone on the floor with hands placed shoulder-width apart with the thumbs above the head position with knees fully extended.
2. Instruct the client to perform one push-up in this starting position.
3. Instruct the client to lift the body as a unit with no lag in the lumbar spine.
4. If the client cannot perform a push-up in this position have him or her lower the hands to the chin and perform a re-assessment.
5. You can perform the assessment as many as 3 times.

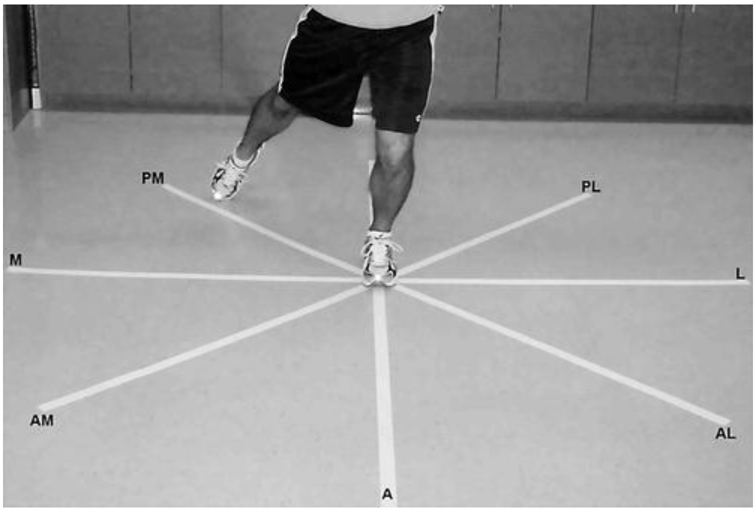
Star Excursion Balance Test

Purpose

To determine balance and postural control in a dynamic test. This functional test is purported to detect functional performance deficits associated with lower extremity pathology in either healthy or impaired clients. It uses a series of lower extremity reaching tasks in up to eight directions that challenge the client's postural control, strength, range of motion and proprioceptive abilities.

Procedure

1. Instruct the client to reach with one lower extremity while balancing on the opposite.
2. Ask the client to reach in 8 different directions at 45 degree increments from the centre of the grid.
3. Instruct the client to reach to the farthest possible point with the distal-most part of the foot.
4. Tell the client to reach as far as possible using the reaching leg to provide support in the maintenance of the upright posture.
5. Instruct the client to return to the upright position after each reach while maintaining equilibrium.
6. Instruct the client not to move the stance foot from its original position.
7. Perform the test for both the dominant and the nondominant limb.



Tinetti Test

Purpose

To determine a client's gait and balance.

Procedure

1. For the balance portion of the examination, have the client seated in a hard armless chair and ask him or her to stand and rise.
2. Score balance according to the Tinetti Assessment Tool for Balance.
3. For the gait portion of the examination, instruct the client to stand and walk down a hallway or across a room at a usual pace and then return at a rapid but safe pace.
4. Score the gait according to the Tinetti Assessment Tool for Gait.

Multiple Single-Leg Hop Stabilisation Test

Purpose

To assess postural control and balance during functional performance with repetitive hoping.

Procedure

1. Set up the floor pattern consisting of 11 square boxes of tape, each box is 2.5cm square and intertape distances.
2. Describe the testing sequence to the client.
3. Allow the client to perform several practice hop stabilisation trials on each leg prior to testing.
4. Have the client stand with the test lower extremity completely covering the start box, the non-test lower extremity flexed slightly at the hip and knee to avoid ground contact and hand on bilateral iliac crests.
5. Allow the client to look briefly at the target location before hoping to tape mark 1.
6. Instruct the client that upon landing, he or she must control balance to remain in single-leg stance with hands on the iliac crests and head remaining level and facing forward.
7. Once the client establishes control begin counting 5 seconds out loud to mark the beginning of the balance period. During this period the client must maintain a stable position, look forward without touching down or moving the non-test leg into excessive flexion (>30°) flexion, abduction or extension.
8. At the end of 5 seconds allow the client again to look at the target location and hop to the next tape mark landing in the standardised position.
9. Have the client perform the hop course on the other leg.

Rotational Stability Assessment

Purpose

To assess multi-planar trunk stability while a combined upper and lower extremity motion is performed.

Procedure

1. Position the client in a quadruped position with shoulders and hops at 90° relative to the upper torso. Bilateral knees are positioned at 90° and ankles remain dorsiflexed.
2. Place a 2x6 board between the knees and hands so they are in contact with the board.
3. Instruct the client to flex the shoulder and extend the same-side hip and knee (first position).
4. Have the client raise the leg and hand enough to clear the testing surface by approximately 6in (15cm).
5. Ensure that the lifted extremities remain in the same plane as the board.
6. Instruct the client to flex the same shoulder and knee so that they touch (second position).
7. Perform the assessment bilaterally up to 3 times.

Up-Down Test

Purpose

To assess the ability to produce speed, balance, and single lower extremity control over a specified vertical and horizontal distance and number or repetitions with specific emphasis on speed in a repetitive up-and-down manner for the single lower extremity.

Procedure

1. Position the client directly in front of a 20cm high step, standing on the test lower extremity.
2. Require the client to hop vertically up and down the step for 10 repetitions as quickly as possible without turning backward.
3. Choose the hand position you prefer (hips/behind back/free) and keep this consistent.
4. Test the non-involved leg before the involved leg.
5. Record the time taken to perform the 10 repetitions to the nearest tenth of a second.

Vertical Jump Test

Purpose

To assess the client's explosive power in a vertical direction.

Procedure

1. Position the client so that he is standing with equal weight on bilateral lower extremities which are approximately shoulder width apart.
2. Have the client push back the highest reachable marker on a Vertec or make a mark on a wall with chalk.
3. Record the mark as the zero starting position.
4. For the jump, choose the hand position you prefer (hips/behind back/free) and keep this consistent.
5. Instruct the client not to move the feet and to flex at the knee, hip and ankle; jump and push back the highest reachable marker on the Vertec or to make a mark on the wall.
6. Record the distance.

Carioca Drill/Test

Purpose

To assess the client's ability to move laterally while crossing the legs in a coordinated fashion as quickly as possible.

Procedure

1. Instruct the client to move laterally with a crossover step across two lengths of the 12m distance.
2. Have the client begin by moving from left to right and then reverse direction following the first 12m length thus performing the test a total of 24m in the minimum amount of time possible.

Lateral Lunge Test

Purpose

To assess lower extremity strength, balance and flexibility.

Procedure

1. Instruct the client to step out to the lateral side leading with the dominant leg.
2. Inform the client that the lunge foot remains perpendicular to the direction of the lunge; the stance leg is to remain extended with the stepping leg flexed slightly at the knee.
3. For scoring, measure from the medial aspect of the stance heel to the medial aspect of the lunge heel.

Double Leg Lowering

Purpose

To assess the ability of the trunk abdominal muscles to function eccentrically and control the lumbopelvic complex and to assess pelvic tilt motor control.

Procedure

1. Position the client in supine, place both lower extremities in a vertical position.
2. Visually observe to ensure the client's anterior superior iliac spines are in the same plane as the pubic symphysis.
3. Palpate the posterior pelvis and lower back area to monitor for tilting of the pelvis.
4. Instruct the client to perform an abdominal contraction with a posterior tilt of the pelvis in order to keep the lumbar spine flat throughout the test and prevent unwanted anterior tilting of the pelvis.
5. As the client lowers bilateral lower extremities to the treatment table while keeping the knees straight, monitor for anterior pelvic tilting.

Timed Sit-Up Test (Sit-Up Endurance Test)

Purpose

To assess trunk abdominal endurance with a dynamic trunk flexion activity over a 1 minute period.

Procedure

1. Position the client in supine with shoulder and head flat on the testing surface.
2. Have the client flex bilateral arms to cross over the chest.
3. At the start of the test, instruct the client to flex the neck toward the chest; the upper trunk is curled toward bilateral thighs until the upper torso is off the surface.
4. Allow the torso to flatten back to the testing surface.
5. Throughout testing, ensure that bilateral feet, buttocks and lower torso are held flat against the testing surface and that bilateral arms are held stationary.
6. Instruct the client to perform this sequence for as many repetitions as possible in a 1 minute period.
7. Record the number of correct repetitions formed in 1 minute. Do not count the repetition if the client fails to reach the up position, fails to maintain the initial testing position or raised the buttocks off the testing position.

Timed Press-Up Test (Timed Push-Up Test)

Purpose

To assess upper body extremity muscular strength and endurance over 1 minute.

Procedure

1. Have the client begin in the prone position with hands shoulder width apart and full weight of the lower body on the toes.
2. Instruct the client to begin with the arms extended while keeping the head, shoulders, back, hips, knees and feet in a straight line.
3. Count a complete push-up when the client's upper arm is parallel to the floor or the lower in the down position and the arms are completely extended in the up position and straight body alignment is maintained.
4. Instruct the client to perform this sequence for as many repetitions as possible in a 1 minute period.
5. Record the number of correct repetitions formed in 1 minute.

Supine Bridge

Purpose

To assess static trunk endurance and control in a supine position.

Procedure

1. Position the client in supine with knees flexed a 90° and the soles of the feet on the testing surface with a narrow base, but not touching; the hands are positioned by the ears.
2. Instruct the client to raise the pelvis from the testing surface so that the shoulders, hips, and knees are maintained in a straight line.
3. Have the client hold the position until prevented from doing so by fatigue or pain.
4. Record time in seconds from initiation of the testing position until the client is no longer able to maintain the position.

Single-leg Supine Bridge

Purpose

To assess static trunk & leg endurance and control in a supine position.

Procedure

1. Position the client in supine with knees flexed a 90° and the soles of the feet on the testing surface with a narrow base, but not touching; the hands are positioned by the ears.
2. Instruct the client to raise the pelvis from the testing surface so that the shoulders, hips, and knees are maintained in a straight line.
3. Next have the client extend their dominant leg removing one point of support.
4. Have the client hold the position until prevented from doing so by fatigue or pain.
5. Record time in seconds from initiation of the testing position until the client is no longer able to maintain the position.
6. Repeat the procedure on the nondominant leg.

Shoulder Mobility Test

Purpose

To assess bilateral shoulder range of motion combining internal rotation with adduction and external rotation with abduction.

Procedure

1. Measure the client's hand length from the wrist crease to the tip of the 3rd digit.
2. Instruct the client to make a fist in bilateral hands with the thumbs inside the fist.

3. Instruct the client to reach with the upper extremities behind the back in an attempt to touch hands together.
4. Measure the distance between the two fists.
5. Perform the assessment as many as 3 times bilaterally.

Step Down

Purpose

To assess the clients' ability to perform a coordinated and controlled eccentric and static stabilisation movement.

Procedure

1. Position the client that that he has both feet on the step.
2. Instruct the client to place hands on the hips and to take a single drop-step forward, leading with the test leg.
3. Instruct the client that the lead foot should hit the ground at the same time the trailing foot leaves contact with the step.

Single-Leg Crossover Hop for Distance Test

Purpose

To assess the ability to produce power, speed, balance and single lower extremity control over a specified distance covered by the single lower extremity and the ability to move laterally. Comparisons can be made from side to side to assess limb symmetry.

Procedure

1. Position the client so that he is standing on a single foot, crossing one of the marking strips with each hop.
2. Instruct the client to perform 3 consecutive hops on one foot, crossing one of the marking strips with each hop.
3. Tell the client to hop as far as possible for all 3 hops and to hold the landing foot stationary on the last hop.
4. Do not allow the client to pause and compose their self between hops.
5. Record as the score the distance from the starting point to the front of the client's foot on the final landing.

Knee Bending in 30 seconds

Purpose

To assess the client's ability to perform repetitive knee bending on one leg, as well as the capability to perform fast changes between eccentric and concentric muscle tone force production over the knee joint.

Procedure

1. Position the client so that he is standing directly behind the tape marking on the floor. The long axes of the feet are aligned with a straight line and the toes are placed on a second perpendicular line.
2. Support the client's fingertips.
3. Instruct the client to bend the test knee without bending forward from the hip until he can no longer see the line along the toes (about 30° of knee flexion)
4. Record the number of knee bends performed in 30 seconds.

Static Balance or Stork Test

Purpose

To assess the ability to balance on the ball of the foot.

Procedure

1. Instruct the client to remove shoes and place hands on hips.
2. Have the client place the nonsupporting foot against the inside of the supporting leg.
3. Give the client 1 minute to practice the test.
4. Ask the client to raise the heel and to balance on the ball of the foot.
5. Start the stopwatch as the heel is raised from the floor.
6. End the test when any of the following occurs: hands come off the hips, supporting foot swivels or moves (hops) in any direction, nonsupporting leg loses contact with the knee or the feel of the supporting foot touches the floor.
7. Record the time the client remains balanced.

Hurdle Step Assessment

Purpose

To assess bilateral mobility and stability of the hips, knees and ankles and proper stride during a stepping motion. The movement requires coordination and stability between the hips and torso during the stepping motion as well as single-leg stance stability.

Procedure

1. Position the client so the he is standing with bilateral feet approximately shoulder width apart.
2. Adjust the hurdle to the height of the client's tibial tuberosity.
3. Align the client's toes directly beneath the hurdle.
4. Ask the client to step over the barrier and touch the heel of the step leg to the floor while keeping the stance knee and hip extended.
5. Perform the assessment as many as 3 times bilaterally.

Active Knee Extension Test (90/90 Hamstring Test)

Purpose

To determine the extensibility, length and excursion of the hamstrings.

Procedure

1. Position the client in supine with the hip flexed to 90°.
2. Place the contralateral lower extremity on the support surface with the knee fully extended and this position must be maintained throughout testing.
3. Instruct the client to actively extend the knee through the full available range of motion until firm muscular resistance is felt while the hip is maintained I 90° of flexion.

4. Align the goniometer with the stationary arm along the femur with the reference point of the greater trochanter of the femur; the axis of the movement arm is the lateral epicondyle at the knee, and the moving arm is aligned with the lateral malleolus.
5. Use the measured angle as the score.

Prone Bridge

Purpose

To assess static trunk endurance and control in a prone position.

Procedure

1. Position the client so that he is in the prone position, propped on the elbows; bilateral elbows are placed shoulder width apart and the feet are set with a narrow base but not touching.
2. Instruct the client to elevate the pelvis from the testing surface so that only the forearms and the toes are in contact with the surface.
3. Have the client maintain the shoulders, hips and ankles in a straight line.
4. Instruct the client to hold this position until prevented from doing so by fatigue or pain.
5. Record the time in seconds from initiation of the testing position until the client is no longer able to maintain this position.

Four Square Step Test

Purpose

To identify balance and vestibular dysfunction. The test incorporates stepping backward, forward and sideways quickly; these movements can be difficult in people with vestibular disorders.

Procedure

1. Use standard or t-shaped canes.
2. Lay the four canes on the ground at 90° angles to each other (like a plus sign).
3. Ask the client with shoes on to stand in one square directly facing the square in front.
4. Instruct the client to travel clockwise around the plus sign by moving forward then to the right then backward then to the left.
5. Instruct the client to reverse the path and repeat the sequence in a counter clockwise direction.
6. Ensure that both feet make contact with the floor in each square.
7. Instruct the client to try to complete the sequence as fast as possible without touching the canes.
8. Tell the client to face forward during the entire sequence.
9. Record the time to complete the sequence.

Romberg Test

To assess balance.

Procedure

1. Instruct the client to stand with feet together, arms at the side and eyes closed while maintaining balance.
2. You can use variations of this test in which the client holds the arms at 90° of abduction, tilts the head backwards, stand on the toes, stands on a single leg or performs the finger-to-nose test.
3. Record the time balance is maintained or record sway or unsteadiness.

Side-Hop Test

Purpose

To assess the ability to produce power, speed, balance and single lower extremity control over a specified lateral and horizontal distance and number of repetitions with specific emphasis on speed in a repetitive lateral manner for the single lower extremity.

Procedure

1. Position the client so that he is standing next to the starting line with the nontest extremity held in some degree of hop and knee flexion to avoid ground contact.
2. Instruct the client to hop transversely or laterally more than 30cm for 10 repetitions as quickly as possible.
3. Choose the hand position you prefer (hands on hips, behind back or free) and be consistent.
4. Record the time taken to perform the 10 repetitions to the nearest tenth of a second.
5. Repeat on the other leg.

Endurance of Lateral Trunk Flexors (Side Bridge)

Purpose

To determine endurance of trunk lateral flexor muscles for side-to-side comparison as well as in comparison ratios with other trunk endurance muscles.

Procedure

1. Position the client in the right side-lying position with the right elbow propped on the table.
2. Have the client extend bilateral legs and place the top foot in front of the lower foot on the table for support.
3. Have the client lift the bilateral hips to align the back, hip and lower extremities.
4. Instruct the client to support himself with the hips lifted to maintain a straight line over the full body length on one elbow and the feet.
5. Have the client hold the uninvolved arm across the chest with the hand of that arm placed on the opposite shoulder.
6. Manually record the endurance time in seconds from the point at which the client assumed the testing position until the hips returned to the starting surface.

One-Legged Cyclic Hop Test

Purpose

To assess the client's ability to repetitively jump or hop off lower extremities for time, height, contact time, and frequency of hops or jump.

Procedure

1. Instruct the client to jump as high as possible and to keep contact with the platform as brief as possible.
2. Instruct the client to jump (both legs) or hop (single leg) and to land on either both legs or on one leg.
3. Instruct the client to keep both hands on the hips to eliminate their use in generating momentum.

Active Straight Leg Raise Assessment

Purpose

To assess active hamstring and gastoc-soleus flexibility while the individual maintains a stable pelvis.

Procedure

1. Position the client so that he is supine with arms at the side, palms up and head flat on the floor.
2. Place a board under the client's knees.
3. Instruct the client to lift the test leg with a dorsiflexed ankle and extended knee.
4. Ensure the opposite leg remains in contact with the board and that the head and shoulders remain flat on the floor.
5. At the client's end-range position, align a dowel along the medial malleolus of the leg and perpendicular to the floor.
6. Perform the assessment as many as 3 times bilaterally.

Single-Leg Hop for Distance

Purpose

To assess overall single lower extremity power for side to side comparison.

Procedure

1. Ask the client to stand with the front of his shoes behind the starting line.
2. You chose your hand position (hands on hips, behind back or free) but keep the hand placement consistent.
3. Ask the client to hop forward as far as possible landing with the knee bent to help decrease the risk for knee injury.
4. Use the spot that marks the placement of the posterior heel to measure hop distance from the starting line.

Figure 8 Hop Test

Purpose

To assess the ability to produce power, speed, balance and single lower extremity control on a horizontal surface in multiple directions (figure 8 pattern) with specific emphasis on speed over the distance covered by the single lower extremity.

Procedure

1. Position the client so that he is standing on the test lower extremity behind the starting line. The opposite leg is held in some hip and knee flexion to avoid foot contact with the floor.
2. Instruct the client to hop in a figure of 8 pattern over a 5m distance as fast as possible.
3. You chose your hand position (hands on hips, behind back or free) but keep the hand placement consistent.
4. Measure the time taken to perform 2 consecutive laps to the nearest tenth of a second.
5. Repeat the procedure on the other leg.

Six-Meter (6m) Timed Hop

Purpose

To assess the ability to produce power, speed, balance and single lower extremity control over a specified distance with specific emphasis on time for the single lower extremity.

Procedure

1. Place 2 pieces of tape on the floor 6m apart to indicate starting and stopping locations.
2. Position the client so that he is standing behind the starting-line tape.
3. You chose your hand position (hands on hips, behind back or free) but keep the hand placement consistent.
4. Instruct the client to perform a single-leg hop over the 6m distance.
5. Encourage large, forceful one-legged propulsive hopping over the distance.
6. End the test when the back of the client's heel crosses the finish line.
7. Measure the time to the nearest 1/100s.
8. Repeated the procedure on the other leg.

Triple Jump for Distance Test

Purpose

To assess the ability to perform a repetitive, explosive jumping movement off of bilateral lower extremities for assessment of repetitive power capacity.

Procedure

1. Position the client so that he is standing with bilateral feet a comfortable distance apart just behind the starting line.
2. Instruct the client to bend and lift one leg at the knee in order to initiate movement with a hop off the single leg.
3. Allow the client to swing bilateral arms as necessary.
4. Have the client perform a maximal triple jump movement (hop onto starting leg, step onto opposite leg, and finish with a bilateral jump movement) along the testing surface.
5. Allow the client to perform a countermovement prior to jumping and ask him to hold the landing to allow the distance to be marked.
6. Measure the distance from the starting line to the back of the heel closest to the starting line.
7. Have the client perform 3 trials with adequate rest for recovery between trials.
8. Record the average of the 3 trials.

Medicine Ball Chest Pass

Purpose

To determine upper extremity strength and power.

Procedure

1. Instruct the client to stand on step behind the starting line.
2. Have the client hold the medicine ball
3. Ask the client to take one step and from chest level pass the medicine ball forward staying behind the starting line.
4. For the score measure from the front of the line to the point where the ball lands.

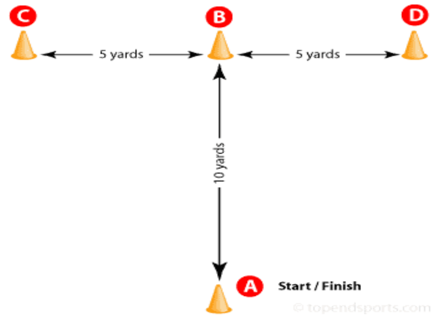
T-Test

Purpose

To test multidirectional speed, agility and body control.

Procedure

1. Instruct the client to sprint 10 yards forward, touching the right hand to the base of the centre cone.
2. Have the client then side shuffle to the left 5 yards and the left hand touches the base of the cone.
3. Have the client shuffle right 10 yards and the right hand touches the base of the cone.
4. Have the client shuffle left to the centre cone and the left hand touches the base of the cone.
5. Have the client finally backpedal past the starting cone and stop the clock.
6. Perform 2 trials and record the best time to the nearest tenth of a second.
7. Allow 1-2 minutes rest between trials.



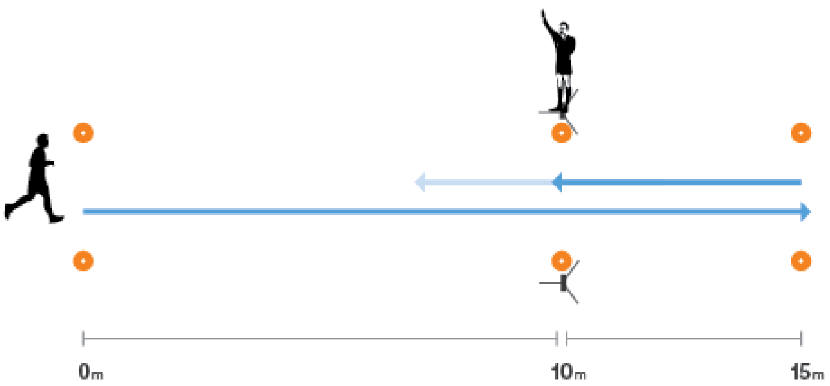
505 Agility Test

Purpose

To test multidirectional speed, agility and body control.

Procedure

1. Instruct the client to begin at the starting line and sprint past the marker cone to the zero line.
2. At this position, require the client to turn on either left or the right foot and then accelerate off the line back to the marker cone.
3. Have the client perform 3 trials turning on the preferred foot.
4. Record to the nearest tenth of a second the time taken to cover the 10m distance from the starting line to the turning point and back.



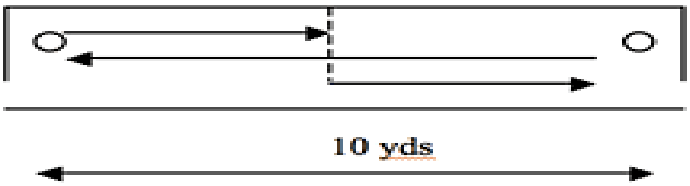
5-10-5 Pro Agility Test

Purpose

To test multidirectional speed, agility and body control.

Procedure

1. Have the client start in a two-point stance straddling the starting line.
2. Instruct the client on the Go command to turn and sprint to the right touching the line 5 yards away with the right hand.
3. Have the client turn to the left, sprint 10 yards and touch the far line with the left hand.
4. Have the client then turn back to the right and sprint 5 yards through the start/finish line and stop the clock.



Edgren Side-Step Test

Purpose

To test lateral speed, agility and body control.

Procedure

1. Have the client stand in a two-point stance, straddling the centre line.
2. Instruct the client to sidestep to the right until his or her right foot has touched or crossed the left outside line.
3. Instruct the client to sidestep to the left until his foot has touched or crossed the left outside line.
4. Have the client continue to sidestep back and forth to the outside lines as rapidly as possible for 10 seconds.
5. Ensure that the client faces forward and side shuffles for the entire test.

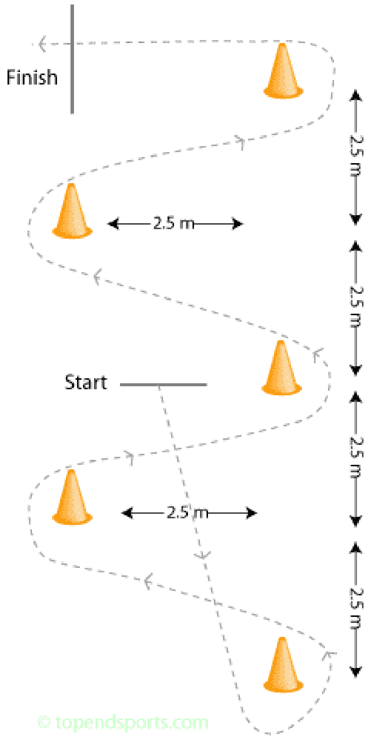
Slalom Test

Purpose

To test multidirectional speed agility and body control.

Procedure

1. Place six hurdles over a 12m distance at 2m intervals.
2. Instruct the client to run at maximum speed in a slalom pattern between the hurdles, both forward and backward to the starting point.
3. Measure from the time the first foot crosses the starting line to the time one of the feet crosses the same line for the last time.



Hurdle Test

Purpose

To test multidirectional speed, agility and body control.

Procedure

1. Place the six hurdles over a 12m distance at 2m intervals.
2. Instruct the client to jump over the first hurdle, crawl under the second, jump over the third and so on until they clear the sixth and final hurdle then sprint directly back to the starting line.
3. Measure from the time the first foot crosses the starting line to the time one of the feet crosses the same line for the last time.

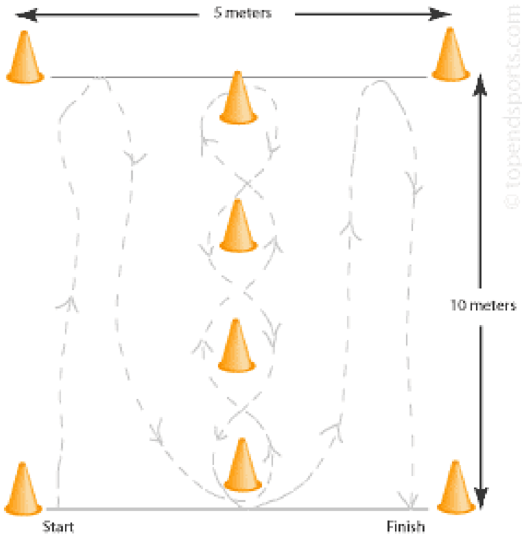
Illinois Agility Test

Purpose

To test multidirectional speed, agility and body control.

Procedure

1. Set up the course, length is 10m and width is 5m (distance between the start and finish points).
2. Use four cones to mark the start, the finish and the two turning points.
3. Place another four cones down the centre, spacing them 3.3m apart.
4. Instruct the client to lie on this stomach (head to the start line) with hands by the shoulders.
5. Instruct the client on the "go" command to get up as quickly as possible and run around the course in the direction indicated, without knocking the cones over, to the finish line.
6. Start timing when you issue the "go" command and stop the times when the client reaches the finish line.



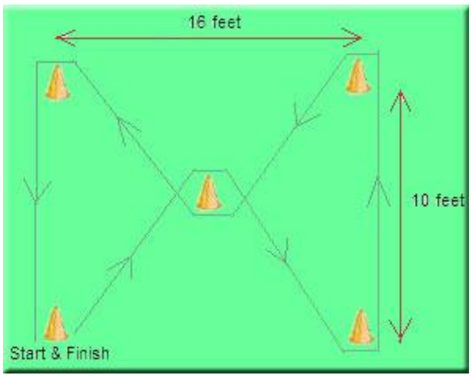
Zigzag Run Test

Purpose

To test power, speed, quickness and body control in multiple planes of movement. The test also assesses lower extremity control including the ability to perform plant and cut types of movement correctly.

Procedure

1. Set up the path, which is 3by4.85m and marked with coloured tape on the floor and place cones in every corner.
2. Position the client so that he is in a ready stance directly behind the starting line.
3. Have the client run one lap as fast as possible around the zigzag path.
4. If the client does not round all cones in completing the one full lap, require them to rest and then retest.
5. Record the time taken to perform one full lap around the path to the nearest tenth of a second.



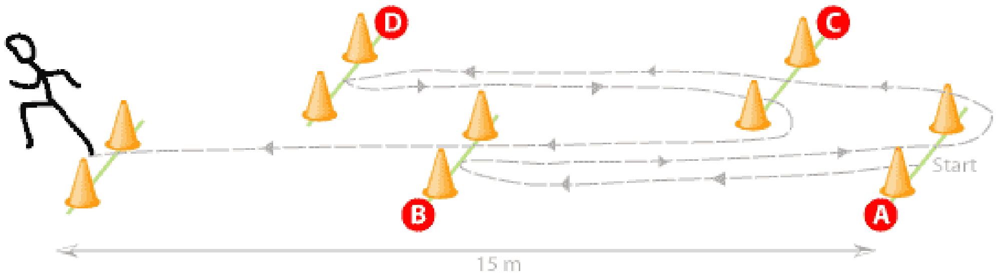
Balsom Run

Purpose

This is a test of speed, body control and the ability to change direction (agility).

Procedure

1. Set up the cones as illustrated in the diagram below to mark the start, finish and the three turning points.
2. The length of the course is 15m (the distance to cones at B, C and D have not been confirmed).
3. The subject starts at A and runs to cones at B before turning and returning to A. Subject then runs through cones at C, turns back at D, and returns through C. The subject turns to the right and runs through cones at B and through the finish.
4. Two trials are allowed and the fastest time recorded.



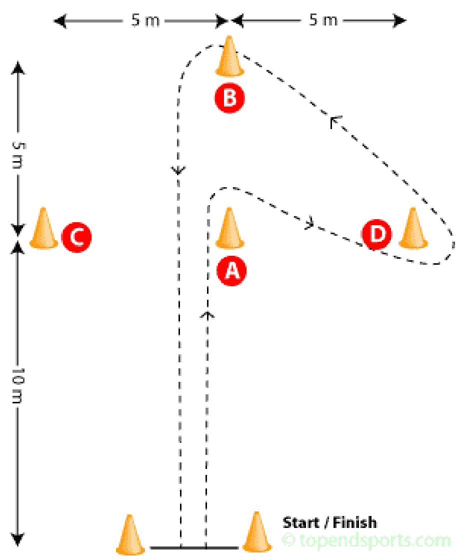
Arrowhead Agility Test

Purpose

This is a test of speed, explosion, body control and the ability to change direction over a range of angles and directions.

Procedure

1. The cones are laid out as per the diagram below, with three marker cones placed in a arrowhead shape, and one set of cones or line marker to indicate the start and finish line.
2. The player starts with their foot behind the starting line in a sprint start position. When ready, they run as fast a possible to the middle cone (A), turn to run around the side cone (C) or (D), around the far cone (B) and back through the start/finish line.
3. The subject completes four trails, two to the left then two to the right (as shown).
4. The trail does not count if they step over a cone instead of around it.
6. Record the best time to complete the test for the left and right turning trails. The time is recorded to the nearest tenth of a second for each direction.



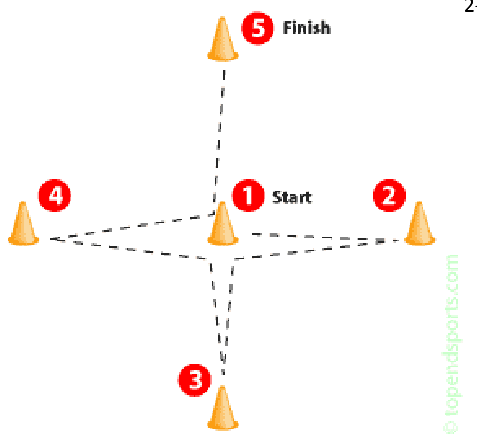
Compass Agility Drill

Purpose

This is a test of speed, explosion, body control and the ability to change direction (agility).

Procedure

1. The cones are laid out with four marker cones placed in a diamond shape, and one in the middle. The outer cones are each placed 3 meters from the center.
2. The player crouches behind and with their left hand on the middle cone, facing forwards (towards cone 5). The player then turns and runs to the right and touches the cone (2) with their hand. They then turn back and run to the center cone, out to the next cone (3), back to the center, out to the next cone (4), back to the center and then finally turn and finish by running through the finish line at cone 5.
3. The player is required to touch the cone with their hand at each turn.
4. Timing starts when the hand comes off the center cone, and stops when the chest passes through the line of the final cone.
5. Rest for three minutes, then repeat the drill, moving in the opposite direction (counterclockwise, cones in order 1-4-3-2-5).



300 Shuttle Run

Purpose

Assessment of anaerobic lower extremity power performed repetitively over a fixed-distance course.

Procedure

1. Position the client directly behind the starting line.
2. Have the client sprint to the 25yrd line to touch the line with the foot, then turn to sprint back to the starting line and touch that line for a total of 6 trips (12x25yd= 300yd/274m).
3. Record the time to the nearest tenth of a second.
4. Have the client rest for 5 minutes and then repeat the test.
5. Record the average of the two test's as the client's time.

Running-Based Anaerobic Sprint Test (RAST)

Purpose

Assessment of anaerobic lower extremity power performed repetitively over a fixed-distance course.

Procedure

1. Have the client positioned directly behind the starting line.
2. For the test, require the client to perform six 35m discontinuous maximal effort sprints.
3. Allow 10 seconds for rest at the tournaround between each sprint.
4. Start the stopwatch as the client begins.
5. Each time the client completes the 35m distance, stop the stopawatch for the 10s rest then start it again.

Squat Jump Test

Purpose

To assess lower extremity anaerobic power with a jumping task.

Procedure

1. Have the client stand with feet a comfortable distance apart.
2. Ask the client to sink to hold a knee position of approximately 120°.
3. Instruct the client that at the count of 4 he should jump as high as possible either to the Vertec or to make a mark with chalk on the wall.

Plyometric Leap Test

Purpose

To assess lower extremity anaerobic power via a plyometric type of leaping motion.

Procedure

1. After a brief warm-up, have the client perform 3 consecutive leaps from a standing position by springing from one foot to the opposite foot.
2. Ask the client to land on both feet after the last leap.
3. Use caution by stressing that the client should land with a bent knee to reduce risk of injury.
4. Record the total distance leaped to the nearest centimetre or metre.

Chester Step Test

Purpose

This is a submaximal test of cardiovascular function that utilizes multiple stages while the heart rate and exertion levels are continuously monitored.

Procedure

1. Review testing procedures with the client before starting the test.
2. Instruct the client to begin with a step rate of 15 steps per minute for 2 minutes (level 1).
3. Record both heart rate and perceived exertion.
4. Then increase the step rate to 20 steps per minute for another 2 minutes (level 2).
5. Again record both heart rate and perceived exertion.
6. Continue testing in this progressive manner until the client reaches an exercising heart rate of 80% of his predicted maximum (220-age).

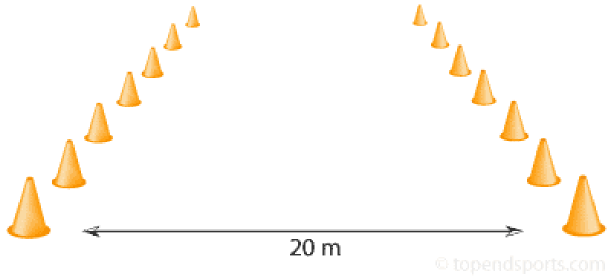
20m Shuttle Run/Multi-Stage Fitness/Bleep Test

Purpose

To determine the client's level of cardiorespiratory fitness.

Procedure

1. Mark a 20m distance with one cone at each end.
2. Instruct the client to carefully listen to the CD and advise the client of the testing criterion, always placing one foot on or behind the 20m mark
    - The CD will emit a beep at the time the client is required to be at the 20m mark.
    - The client must try to be at the opposite end of the 20m track by the time the next beep sounds.
    - The client's running speed will have to be gradually increased because the time interval between beeps decreases after approximately each minute.
3. Start the CD and instruct the client to begin the test.
4. Warn the client if he is unable to reach the 20m mark in time for the beep; terminate the test when the client is unable to reach the 20m mark twice in succession.



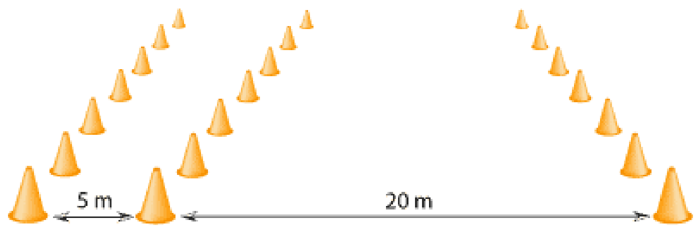
Yo-Yo Intermittent Recovery Test (10 second rest period)

Purpose

The test evaluates an individual's ability to repeatedly perform intervals over a prolonged period of time, particularly for athletes from sports such as tennis, team handball, basketball and soccer or similar sports.

Procedure

1. Use cones to mark out three lines; 20 meters and 5 meters (recovery test) apart.
2. The subject starts on or behind the middle line, and begins running 20 m when instructed by the cd.
3. The subject turns and returns to the starting point when signaled by the recorded beep. There is a active recovery period (10 seconds for the recovery version of the test) interjected between every 20 meter (out and back) shuttle, during which the subject must walk or jog around the other cone and return to the starting point.
4. A warning is given when the subject does not complete a successful out and back shuttle in the allocated time, the subject is removed the next time they do not complete a successful shuttle.



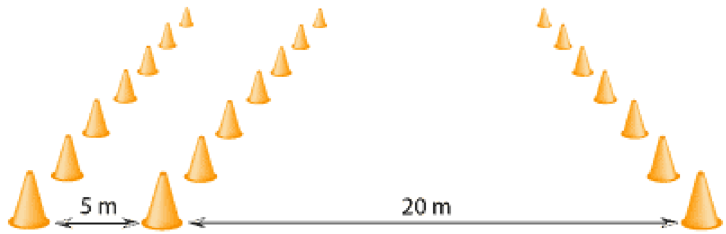
Yo-Yo Intermittent Endurance Test (5 second rest period)

Purpose

The test evaluates an individual's ability to repeatedly perform intervals over a prolonged period of time, particularly for athletes from sports such as tennis, team handball, basketball and soccer or similar sports.

Procedure

1. Use cones to mark out three lines; 20 meters and 2.5 (endurance test) apart.
2. The subject starts on or behind the middle line, and begins running 20 m when instructed by the cd.
3. The subject turns and returns to the starting point when signaled by the recorded beep. There is a active recovery period (5 seconds for the endurance version of the test) interjected between every 20 meter (out and back) shuttle, during which the subject must walk or jog around the other cone and return to the starting point.
4. A warning is given when the subject does not complete a successful out and back shuttle in the allocated time, the subject is removed the next time they do not complete a successful shuttle.



12 Minute Run

Purpose

To determine the client's level of cardiorespiratory fitness. This is an alternative assessment that allows for use of a set period of time and scoring according to distance versus marking a set distance and using times as the assessment.

Procedure

1. Review the testing procedures with the client before beginning the test. Inform the client that he is allowed to walk or rest during the test if necessary but this will affect the score on the assessment.
2. Instruct the client to run continuously for a 12 minute period over a set course marked for distance. Advise the client to cover as much distance as possible over this 12 minute period.
3. Start the stopwatch as soon as the client begins the test and top it at the 12 minute mark.
4. Record the distance covered.

Loughborough Intermittent Shuttle Test

Purpose

To assess the physiological responses of athletes to a simulated sprint based team sport.

Procedure

1. Preliminary testing is required to determine the participant's VO2max for calculation of relative running speeds (you could use the beep test).
2. Marker cones are set up 20 m apart, with timing gates at 15 m from one end.
3. Part A is of is of fixed duration and consists of 5 x 15 minute exercise periods separated by three minutes of recovery.
4. Each exercise period consist of a set pattern of intermittent high-intensity running: 3 x 20m at walking pace, 1 x 20m at maximal running speed, 4 seconds recovery, 3 x 20m running at 55% of VO2max, then 3 x 20m at 95% of VO2max.
5. Part B of the test is an open-ended period of intermittent shuttle running. The participants run continuously between the 20m markers, alternating at speeds of 55% and 95% of VO2max every 20m.
6. This part is designed to last approximately 10 minutes, and continues until they are unable to maintain the required sped for two consecutive shuttles at the higher intensity.

Sprint Fatigue Test

Purpose

This is a test of anaerobic capacity, the ability to recover between sprints and produce the same level of power repeatedly.

Procedure

1. Marker cones and lines are placed 30 meters apart to indicate the sprint distance. Two more cones placed a further 10 meters on each end.
2. At the instructions of the timer, the subject places their foot at the starting line, then on 'go' two stopwatches are started simultaneously, and the subject sprints maximally for 30m, ensuring that they do not slow down before reaching the end.
3. One stopwatch is used to time the sprint, the other continues to run. Record the time.
4. The subjects use the 10 meter cone to slow down and turn, and return to the 30m finishing point. The next sprint will be in the opposite direction.
5. The next 30 meter sprint starts 30 seconds after the first started.
6. This cycle continues until 10 sprints are completed, starting at 30 sec, 1 min, 1.5 min, 2 min etc after the start of the first sprint.

Lumbar Erector Spinae Assessment

Purpose

To determine the range of motion of the lumbar erector spinae.

Procedure

1. Position the client so that he is long sitting on a testing surface keeping the pelvis as vertical as possible.
2. Stand to the side of the client and monitor the movement.
3. Ask the client to forward bend at the lumbopelvic region and move the forehead toward the knees (position one).
4. For the second part of the assessment, have the client sit at the end of the table with bilateral knees flexed.
5. Ask the client to forward bend as far as possible moving the forehead toward the knees without moving the pelvis (position two).
6. Measure the distance from the forehead to the knees with both positions.

Quadratus Lumborum Assessment

Purpose

To determine the extensibility, length and excursion of the quadratus lumborum.

Procedure

1. Position the client so that he is lying on the nontest side with the bottom leg bent slightly at the hip and knee for stability.
2. Stand in front of the client and monitor the quadratus lumborum muscle & iliac crest.
3. Have the client extend the top leg beyond the edge of the table and allow the top (test) leg to drop toward the floor.
4. Measure the distance from the medial femoral epicondyle of the knee to the floor.

Ober’s Test-Iliotibial Band Assessment

Purpose

To determine the extensibility, length and excursion of the iliotibial band.

Procedure

1. Position the client so that he is side-lying with the test side up.
2. Have the client bend the downside of the leg to allow a more stable base to prevent trunk and total-body rotation.
3. Ensure that alignment is in the frontal plane throughout the body, not allowing for rotation or hip flexion compensation.
4. Maintain the client in a frontal plane alignment not allowing rotation at the trunk.
5. Stabilise the ipsilateral hip and hold the client’s leg with the caudal hand on the medial surface of the knee.
6. Flex the client’s knee to 20° and slightly externally rotate the hip to bring the iliotibial band over the greater trochanter.
7. Also abduct the hip slightly prior to the initiation of the testing movement.
8. While maintaining the cranial hand on the hip for stabilisation gradually lower (or adduct) the client’s thigh to end range (typically indicated by iliac crest movement).
5. Measurement options: Measure the distance from the medial femoral epicondyle of the knee to the floor or use the criteria that normal movement is a drop in 10°, anything above this is indicative of tightness.

Internal Rotators of the Hip Assessment

Purpose

To determine the extensibility, length and excursion of the internal rotators of the hip.

Procedure

1. Position the client so that he is prone on the testing surface.
2. Passively flex the knee to 90°.
3. Have the stationary arm of the goniometer running parallel to the testing surface and the moveable arm running parallel to the tibia of the testing limb.
4. Palpate the opposite PSIS and passively externally rotate the limb being tested.
5. Take the measurement when you note rotation of the pelvis.

External Rotators of the Hip Assessment

Purpose

To determine the extensibility, length and excursion of the external rotators of the hip.

Procedure

1. Position the client so that he is prone on the testing surface.
2. Passively flex the knee to 90°.
3. Have the stationary arm of the goniometer running parallel to the testing surface and the moveable arm running parallel to the tibia of the testing limb.
4. Palpate the opposite PSIS and passively internally rotate the limb being tested.
5. Take the measurement when you note rotation of the pelvis.

Kendall's Test

Purpose

To determine the extensibility, length and excursion of the hip flexors and rectus femoris.

Procedure

1. Position of the client lying supine with back flat against the treatment table with the testing legs knee flexed over the end of the table and the other leg passively flexes at the hip towards the athletes chest and flexed at the knee.
2. Position of the tester lateral to the athlete to view the testing leg.
3. Positive Test is indicated by the thigh lifting off the table or the knee extending over 70°. Implications: Thigh lifting off the table -- Hip flexor tightness; Knee extending -- Rectus femoris tightness.

Thomas Test

Purpose

To determine the extensibility, length and excursion of the hip flexors.

Procedure

1. Position the client so that he is supine, with his pelvis level and square to his trunk.
2. Have the client flex both his hips, bringing his thighs up onto his trunk.
3. Have the client hold one leg to his chest and let his other leg down until it is flat on the table. If the thigh rises off the table, the test is positive for a hip flexion contracture.
4. This test does not differentiate between tightness of the iliopsoas versus the rectus femoris.

Modified Thomas Test

Purpose

To determine the extensibility, length and excursion of the hip flexors.

Procedure

1. Position the client so that he is supine, with his pelvis level and square to his trunk and his knees are approximately four inches off the edge of the plinth/table.
2. Have the client flex both his hips, bringing his thighs up onto his trunk.
3. Have the client hold one leg to his chest and let his other leg down until it is flat on the table. If the thigh rises off the table, attempt to flex the knee on that side.
4. If the knee flexes easily, the tight hip flexor is the iliopsoas (positive test for iliopsoas). If you are unable to flex the knee, or resistance is felt, the rectus femoris is tight (positive test for rectus femoris).

Piriformis Test

Purpose

To determine the extensibility, length and excursion of the piriformis.

Procedure

1. Position the client so that he is supine on a stable testing surface with bilateral lower extremities extended.
2. Passively flex the client's hip to 90° then adduct and internally rotate to the end range of the movement.
3. Normal length allows the hip to flex to 90°, adduct 20° and internally rotate to 20°.

Gastrocnemius Test

Purpose

To determine the extensibility, length and excursion of the gastrocnemius.

Procedure

1. Position the client so that he his supine with the hip and knee extended.
2. Dorsiflex the client's ankle trough full available range of motion while maintaining the knee in full extension.
3. Maintaining full extension perform passive dorsiflexion of the ankle.

4. Palpate the following landmarks and align the goniometer accordingly: stationary arm at the head of the fibula, the axis at the lateral malleolus and the moving arm is parallel to the fifth metatarsal.
5. Ensure that the knee remains in full extension during dorsiflexion.
6. Maintain subtalar neutral; this is thought to allow for pure dorsiflexion by avoiding pronation & supination.
7. Use the goniometric measurement as the score.

Soleus Test

Purpose

To determine the extensibility, length and excursion of the soleus.

Procedure

1. Position the client so that he his supine with the hip and knee flexed to about 45°.
2. Place the opposite lower extremity on the support surface with the knee extended.
3. Dorsiflex the client's ankle trough full available range of motion while maintaining the hip and knee flexion of 45°.
4. Maintaining the hip and knee flexion of 45° perform passive dorsiflexion of the ankle.
5. Palpate the following landmarks and align the goniometer accordingly: stationary arm at the head of the fibula, the axis at the lateral malleolus and the moving arm is parallel to the fifth metatarsal.
6. Ensure that the knee remains in full extension during dorsiflexion.
7. Maintain subtalar neutral; this is thought to allow for pure dorsiflexion by avoiding pronation & supination.
8. Use the goniometric measurement as the score.
9. The test can also be measured in prone position with the client's knee bent to 90°.

Sit & Reach Test

Purpose

To measure of flexibility, and specifically measures the flexibility of the lower back and hamstring muscles.

Procedure

1. This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed.
2. The soles of the feet are placed flat against the box. Both knees should be locked and pressed flat to the floor - the tester may assist by holding them down.
3. With the palms facing downwards, and the hands on top of each other or side by side, the subject reaches forward along the measuring line as far as possible.
4. Ensure that the hands remain at the same level, not one reaching further forward than the other.
5. After some practice reaches, the subject reaches out and holds that position for at one-two seconds while the distance is recorded.
6. Make sure there are no jerky movements

Height

Purpose

To determine the client's height.

Procedure

1. Have the client stand upright with their head level and looking straight ahead with bare feet.
2. Record height using a stadiometer to the nearest 0.5cm.

Weight

Purpose

To determine the client's weight/body mass.

Procedure

1. Have the client stand bare foot on analogue scales wearing shorts and a t-shirt.
2. Record weight to the nearest 0.1kg.

Body Mass Index (BMI)

Purpose

The body mass index is a simple measurement to help determine relationship of body height and mass.

Procedure

1. Obtain client's body weight in kilograms (kg) and height in meters (m).
2. Calculate BMI using the following formula: BMI=Body weight (kg) / Height (m^2).

Body Fat-Skin Callipers

Purpose

To measure skinfolds to calculate how much subcutaneous fat (fat under the skin) of a client.

Procedure

1. Measurements can be taken from 3 to 9 different standard anatomical sites around the body.
2. The right side is usually only measured (for consistency).
3. The tester pinches the skin at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle.
4. The calipers are then applied 1 cm below and at right angles to the pinch, and a reading in millimeters (mm) taken two seconds later.
5. The mean of two measurements should be taken. If the two measurements differ greatly, a third should then be done, then the median value taken.

Thigh Girth

Purpose

To measure circumference thigh via specific landmarks on corresponding body parts.

Procedure

1. Mark the site to be measured.
2. Ensure to use standardisation of pull on the tape measure-not too tight and not too loose.
3. Make sure the tape is lying horizontal and is in contact the skin whenever possible and appropriate.
4. Have the client stand with legs slightly parted.
5. Take the circumference measure 2cm below the gluteal line (buttock crease) with the tape horizontal.

Calf Girth

Purpose

To measure circumference calf via specific landmarks on corresponding body parts.

Procedure

1. Mark the site to be measured.
2. Ensure to use standardisation of pull on the tape measure-not too tight and not too loose.
3. Make sure the tape is lying horizontal and is in contact the skin whenever possible and appropriate.
4. Have the client stand with legs slightly parted.
5. Take the measurement from the widest part of the calf.

Torso Height Assessment

Purpose

To determine the height of the client's torso. The test has a potential for comparison to other body parts as well as for use in testing in relationship to trunk endurance.

Procedure

1. Have the client sit on the edge of table with his back as straight as possible.
2. Apply athletic tape over the spinous processes of the client's entire lumbar spine.
3. Wrap string around the index fingers of both your hands and palpate the surface of bilateral iliac crest with your index fingers.
4. A second tester then approximates the string to the athletic tape running over the spinous processes and places a marker over the intersection with a marker.
5. Measure the distance from the apex of the client's head to the mark on the athletic tape.
6. Record the measurement to the nearest 0.5cm.

Y Balance Test

Purpose

To measuring pre and post rehabilitation performance, improvement after performance enhancement programs, dynamic balance and return to sport readiness.

Procedure

1. Player stands with hands on hips and both legs on the ground with the centre of one foot placed in the centre of the axis (centre of foot equates to 2nd toe and middle of medial border of foot as measured using a tape – measured and marked by student) and other foot placed beside it
2. Three practice trials are undertaken on each leg in each direction
3. Recording: Player is instructed to 'reach as far as possible along each line' and the furthest distance reached is recorded
4. A recovery of 10 seconds is taken between each test with 3 tests undertaken in each position on each leg

Invalid Trials:

• Hands are removed from the hips
• Does not return to the start position
• Applies too much weight through the reach foot
• Places the reach foot on the ground either side of the line
• Raises/moves the stance foot during the test

Dorsiflexion Lunge Test

Purpose

To measure functional ankle dosiflexion in a weight bearing position.

Procedure

1. The athlete stands against wall with about 10cm between feet and wall.
2. They move one foot back a foot's distance behind the other.
3. They bend the front knee until it touches the wall (keeping the heel on ground).
4. If knee cannot touch wall without heel coming off ground, move foot closer to wall then repeat.
5. If knee can touch wall without heel coming off ground, move foot further away from wall then repeat.
6. Keep repeating step 5 until can just touch knee to wall and heel stays on ground.
7. Measure either: a) Distance between wall and big toe (<9-10cm is considered restricted) **or** b) The angle made by anterior tibia/shin to vertical (<35-38 degrees is considered restricted)
8. Change the front foot and test the other side (symmetry is ideal)

Appendix 2-Opening Email *Phase 1A*-Round 1

Dear colleague,

I am writing to invite you to participate in a **Doctoral Study on Functional Movement Screening for Football**. As a Physiotherapist working in Premiership football **your experience is crucial** in order to further the research in this area.

This study will help to establish the current clinical application of functional movement screening in football and consequently help to identify specific tests to be included in a football specific functional screening tool. If you are currently working in premiership football and use or have used functional screening tests, I would like to invite you to participate in the study.

Participation in this study will require you to:

- Be a part of a virtual consensus panel.
- This will involve you initially completing an online questionnaire (http://www.surveymonkey.com/s/FMFOOTBALL) that should take no longer than 30 minutes.
- Most of the questions will involve you selecting tests which you feel are appropriate to include in a functional movement screening tool for football.
- After completing the questionnaire you will be asked to review a document which will summarise screening tests identified by all clinicians.
- You will then be asked to once again select tests which you feel are appropriate for inclusion into a functional movement screening tool for football. Full details can be found on the attached information sheet.

The study will be conducted by myself, Erin Morehead (MSc Sports Med; BSc (Hons) Physio) and supervised by Professor Jim Richards & Professor James Selfe of The University of Central Lancashire. I have spent over 6 years working in professional sport, 5 of which have been in football at both club and national level.

All data collected, other than for direct communication purposes to each participant from myself, will remain anonymous throughout the study.

Thank you for considering participation in the study. If you have any further questions, please do not hesitate to contact me. If there is more than one Physiotherapist working at your club, I would be grateful if you could please send me a contact email address for them, so I can invite them to participate in the study.

Please see attached information sheet for full study details. If you wish to participate, you do not need to reply to this email, simply click on the link below. The online questionnaire will be open until Friday January 13th, 2012.

http://www.surveymonkey.com/s/FMFOOTBALL

Kind Regards,

Erin Morehead

<u>Appendix 3-Information Sheet *Phase 1A*</u>

Title of main Professional Doctorate study

Development of a Functional Movement Screening Tool for Football

Aim of this study

This study aims to establish the current clinical practice of Physiotherapists in the UK for functional movement screening techniques of football players.

Objectives of the Professional Doctorate study

Objectives

1. To select a group of clinical experts to form a consensus panel.
2. To determine which tests could be included in a functional movement screening tool
3. To establish consensus within the group of clinical experts as to which tests will be included in the functional movement screening tool.

This will inform the Doctoral phase of the overall study and allow us to establish a functional movement screening tool that is specific for football.

Who will conduct the research?

Erin Morehead, MSc Sports Medicine, BSc (Hons) Physiotherapy, will be responsible for the management of the study. Erin Morehead will also be responsible for recruitment and data collection. Erin is an active Physiotherapist who works both as a Senior Lecturer and Senior Physiotherapist. Erin spent 6 years working in professional sport, 5 which were in football at both club and national level. The study will be supervised by Professor Jim Richards and Professor James Selfe.

What we will ask you to do

We are asking you to participate in a consensus panel. Initially you will be asked to complete a short online questionnaire in relation to the aim of the study. The entire questionnaire should take no longer than 30 minutes to complete. Most of the questions will involve you selecting tests which you feel are appropriate to include in a functional movement screening tool for football but there is space for you to expand your answers depending on your personal experience in this area.

The questionnaire contains a series of focussed questions around the subject of functional movement screening and your use and thoughts of functional movement screening in football. Information given will be used to inform a study of specific identifiable tests which may be included in a functional movement screening tool which will then be used in a clinical study.

After completing the questionnaire you will be asked to review a document which will summarise screening tests identified by all clinicians. You will then be asked to once again select tests which you feel are appropriate for inclusion into a functional movement screening tool for football. Once appropriate tests have been identified for inclusion, you will then be asked to give feedback on proposed instructions for completing each test and an appropriate scoring system for each test.

All data collected, other than for direct communication purposes to each participant from myself, will remain anonymous throughout the study. You are free to withdraw from the study at any time, without providing a reason.

Upon completion of the study the results will be submitted to a peer reviewed journal and national/international conferences. The finding will also be made available to the recruited group.

Eligibility Criteria

The criteria for inclusion for the study are; that you currently work in Premiership Football; you use, or have used, functional movement screening techniques; you are prepared to participate in a questionnaire & consensus panel.

Are you currently working in Premiership Football?	Yes No
Do you use, or have you used any form of functional movement screening techniques?	Yes No
Are you prepared to participate in a questionnaire & consensus panel aimed at this target group and testing?	Yes No

Are there any risks or benefits?

There are no foreseeable risks to you by completing the questionnaire. There will be no immediate direct benefits for you; however the results may help to develop a functional movement screening tool which is specific to football, which may in the future help your clinical practice.

Data storage

All data will be stored in line with UCLAN regulations. Electronic data will anonymised and stored on password-protected computers. All consent forms and other documents will be stored so that no names can be associated with them in a locked filling cabinet. Electronic data and forms will be kept for 5 years following the end of the project.

Who has approved this study?

This study has been approved by the Faculty of Health Ethics Committee.

Who can I contact to discuss any issues or to make a complaint?

If you wish to discuss any aspect of this project you are welcome to contact Erin Morehead, or if you have any issues with the conduct of the staff taking part in this study you can contact Jim Richards (Director of Studies).

Erin Morehead

University of Central Lancashire

Preston

PR1 2HE

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Jim Richards

University of Central Lancashire

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Tel: 01772 894575

Appendix 4- Online Survey *Phase 1A*-Round 2

Functional Movement Screening for Football (Round 2)

1. Do you think the following test(s) should be included in a Functional Movement Screening Tool for Football? (Please remember to see document in the email for this survey which has descriptions of each test if you are unfamiliar with them)

	Yes	No
Deep Squat	☐	☐
Single Leg Squat	☐	☐
Triple Hop for Distance	☐	☐
In-line Lunge	☐	☐
Trunk Stability Push Up	☐	☐
Star Excursion Balance Test	☐	☐
Y-Balance Test	☐	☐
Multiple Single-leg Hop Stabilisation test	☐	☐
Rotational Stability (Prone Kneeling)	☐	☐
Vertical Jump Test	☐	☐
Lateral Lunge Test	☐	☐
Supine Bridge	☐	☐
Single-leg Supine Bridge	☐	☐
Step Down	☐	☐
Hurdle Step	☐	☐
Endurance of Lateral Flexors (Side Plank)	☐	☐
Active Straight Leg Raise	☐	☐
Single-leg Hop for Distance	☐	☐
Dorsiflexion Lunge Test	☐	☐

2. Do you think Agility testing should be included in a Functional Movement Screening Tool for Football?

	Yes	No
	☐	☐

3. Regardless of your answer to Question 2, if Agility tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:

	Yes	No
T-Test	☐	☐
Slalom Test	☐	☐

4. Do you think Muscle Length testing should be included in a Functional Movement Screening Tool for Football?

	Yes ☐	**No** ☐
5. Regardless of your answer to Question 8, if Muscle Length tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Adductor/Groin Flexibility Test	☐	☐
Internal Rotators of the Hip Assessment	☐	☐
External Rotators of the Hip Assessment	☐	☐
Modified Thomas Test	☐	☐
Piriformis Test	☐	☐
Gastrocnemius Test	☐	☐
Soleus Test	☐	☐
6. Do you think Anthropometric testing should be included in a Functional Movement Screening Tool for Football?		
	Yes ☐	**No** ☐
7. Regardless of your answer to Question 10, if Anthropometric tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Height	☐	☐
Weight	☐	☐
Body Mass Index	☐	☐
Body Fat-Skin Callipers	☐	☐
Thigh Girth	☐	☐
Calf Girth	☐	☐

Appendix 5- Opening Email *Phase 1A*-Round 2

Dear colleague,

Welcome to the second and final round of the Doctoral study on Functional Movement Screening in Football. If you completed the first online questionnaire, please read the email below. If you chose not to participate in the study, please disregard this email.

Thank you for participating in the first survey. All tests which were selected to be included into the screening tool by 50% of the participants or more, have now been put into a new online survey. Two additional tests (Y Balance Test & Dorsiflexion Lunge Test) have been added to the survey based on participant feedback. You will once again be asked to select the tests which you feel should be included into a Functional Screening Tool for Football.

In order to complete the study, please click on the link below. The survey should take no longer than 10-15 minutes to complete. This is the last survey you will be asked to complete.

http://www.surveymonkey.com/s/FMFOOTBALL2

All data collected, will remain anonymous throughout the study.

Thank you for your time and participation. If you have any further questions, please do not hesitate to contact me.

Please see attached information sheet for full study details. The online questionnaire will be open until Friday February 17th, 2012.
Kind Regards,

Erin Morehead

Erin Morehead MSc (Sports Med), BSc(Hons) , MCSP, HPC Senior Lecturer in Physiotherapy, Strength & Conditioning, Sports Therapy Brook Building, BB119 School of Sport, Tourism and The Outdoors University of Central Lancashire Preston
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Appendix 6- Information Sheet *Phase 1B*

Title of Main Professional Doctorate study

Development of a Functional Movement Screening Tool for Football

Aim of this study

The aim of Phase 1A was to establish which tests should be included in a functional movement screening tool for football.

After establishing which tests were to be included in the functional movement screening tool in Phase 1A, Phase 1B aims to establish operational definitions of each test and to determine a scoring system for the functional movement screening tool for football.

Objectives of the Professional Doctorate study

Completed Objectives-Phase 1A

4. To select a group of clinical experts to form a consensus panel.
5. To determine which tests could be included in a functional movement screening tool
6. To establish consensus within the group of clinical experts as to which tests will be included in the functional movement screening tool.

Current Objective-Phase 1B

1. To determine operational definitions for evaluating correct performance for each test included in the functional movement screening tool.
2. To establish a scoring system for measuring performance on each of the tests to be included in the functional movement screening tool.

Who will conduct the research?

Erin Morehead, MSc Sports Medicine, BSc (Hons) Physiotherapy, will be responsible for the management of the study. Erin Morehead will also be responsible for recruitment and data collection. Erin is an active Physiotherapist who works both as a Senior Lecturer and Senior Physiotherapist. Erin spent 6 years working in professional sport, 5 of which were in football at both club and national level. The study will be supervised by Professor Jim Richards and Professor James Selfe.

What we will ask you to do

Thank you for completing the online questionnaires which have established the tests that will be included into a functional movement screening tool for football. You will now be asked to review a document which summarises the proposed operating procedures for the screening tests that have been included. You will be asked to give feedback on the proposed instructions for completing each test. You will also be asked to discuss appropriate scoring systems for each test.

All data collected, other than for direct communication purposes to each participant from myself, will remain anonymous throughout the study. You are free to withdraw from the study at any time, without providing a reason. Confidentiality of the study's operations & findings is expected from participants throughout the study. Please note that the University of Central Lancashire holds the intellectual property rights to this study, and the University treats any breach in confidentiality seriously.

Upon completion of the study the results will be submitted to a peer reviewed journal and national/international conferences. The finding will also be made available to the recruited group.

Eligibility Criteria

The eligibility criteria for inclusion in the study remain the same as for Phase 1A. The study requires that you currently work in Premiership Football; you use, or have used, functional movement screening techniques; and that you are prepared to participate in a virtual consensus panel.

Are you currently working in Premiership Football?	Yes No
Do you use, or have you used any form of functional movement screening techniques?	Yes No
Are you prepared to participate in a consensus panel aimed at this target group?	Yes No

Are there any risks or benefits?

There are no foreseeable risks to you by completing the questionnaire. There will be no immediate direct benefits for you; however the results may help to develop a functional movement screening tool that is specific to football, which may in the future help your clinical practice.

Data storage

All data will be stored in line with UCLAN regulations. Electronic data will anonymised and stored on password-protected computers. All consent forms and other documents will be stored so that no names can be associated with them in a locked filling cabinet. Electronic data and forms will be kept for 5 years following the end of the project.

Who has approved this study?

This study has been approved by the Faculty of Health Ethics Committee.

Who can I contact to discuss any issues or to make a complaint?

If you wish to discuss any aspect of this project you are welcome to contact Erin Morehead, or if you have any issues with the conduct of the staff taking part in this study you can contact Jim Richards (Director of Studies) or James Selfe.

Erin Morehead	**Professor Jim Richards**	**Professor James Selfe**
University of Central Lancashire	**University of Central Lancashire**	**University of Central Lancashire**
Preston	**Preston**	**Preston**
PR1 2HE	**PR1 2HE**	**PR1 2HE**
Email: ekmorehead@uclan.ac.uk	**Email: jrichards@uclan.ac.uk**	**Email: Jselfe1@uclan.ac.uk**
Tel: 01772 894562	**Tel: 01772 894575**	**Tel: 01772 894751**

Appendix 7- Consent Form *Phase 1B*

uclan

Study Title: Development of a Functional Movement Screening Tool for Football

Initial

Principal investigator: Erin Morehead

Please read all the statements below and initial each box to confirm that you have read and understood each item

1. I confirm that I have read and understood the information sheet for the above study; I have had the opportunity to consider the information and ask questions and have had these answered satisfactorily ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without it affecting my legal rights. ☐

3. I agree to:

Taking part in an online consensus panel ☐

Allow anonomised quotes to be used in further research, in reports, publications or for teaching purposes. ☐

Keep the study's operations & findings confidential ☐

______________________	____________	______________________
Name of Participant	Date	Signature
______________________	____________	______________________
Name of Researcher	Date	Signature

Appendix 8- Ethics Approval Letter *Phase 1*

29th July 2011

Jim Richards/Erin Morehead/James Selfe

School of Health

University of Central Lancashire

Dear Jim, Erin & James

Re: Faculty of Health & Social Care Ethics Committee (FHEC)

Application - (Proposal No.514)

The FHEC has granted approval of your proposal application 'Development of a functional movement screening tool for Football' on the basis described in its 'Notes for Applicants'.

We shall e-mail you a copy of the end-of-project report form to complete within a month of the anticipated date of project completion you specified on your application form. This should be completed, within 3 months, to complete the ethics governance procedures or, alternatively, an amended end-of-project date forwarded to Research Office.

Yours sincerely

Peter Robinson

Deputy Vice Chair

Faculty of Health Ethics Committee

Appendix 9- Results of Online Survey *Phase 1A*-Round 1

Functional Movement Screening for Football (Results Round 1)

1. Do you think the following test(s) should be included in a Functional Movement Screening Tool for Football? (Please remember to see document in the email for this survey which has descriptions of each test if you are unfamiliar with them)

	Yes	No
Deep Squat	100%	0%
Standing Long Jump	21.43%	78.57%
Functional Reach	28.57%	71.43%
Single Leg Squat	100%	0%
Triple Hop for Distance	57.14%	42.86%
Hexagon Test	7.14%	92.86%
In-line Lunge	85.71%	14.29%
Tandem Walking	0%	100%
Side Step Test	7.14%	92.86%
Trunk Stability Push Up	57.14%	42.86%
Star Excursion Balance Test	64.29%	35.71%
Tinetti Test	0%	100%
Multiple Single-leg Hop Stabilisation test	64.29%	35.71%
Rotational Stability (Prone Kneeling)	57.14%	42.86%
Up-Down Test	7.14%	92.86%
Vertical Jump Test	78.57%	21.43%
Carioca Drill/Test	14.29%	85.71%
Lateral Lunge Test	50.00%	50.00%
Double Leg Lowering	21.43%	78.57%
Timed Sit Up Test	0%	100%
Timed Press Up Test	0%	100%
Supine Bridge	50.00%	50.00%
Single-leg Supine Bridge	78.57%	21.43%
Shoulder Mobility Test	42.86%	57.14%
Step Down	64.29%	35.71%
Single-leg Cross Over Hop for Distance	42.86%	57.14%
Knee Bending in 30seconds	0%	100%
Static Balance-Stork Test	28.57%	71.43%
Hurdle Step	78.57%	21.43%
Active Knee Extension-90/90 Hamstring	42.86%	57.14%

Test		
Prone Bridge (Plank Test)	42.86%	57.14%
4 Square Step Test	7.14%	92.86%
Romberg Test	0%	100%
Side Hop Test(timed)	7.14%	92.86%
Endurance of Lateral Flexors (Side Plank)	50.00%	50.00%
One-Leg Cyclic Hop Test	14.29%	85.71%
Active Straight Leg Raise	64.29%	35.71%
Single-leg Hop for Distance	64.29%	35.71%
Figure 8 Hop Test	7.14%	92.86%
6m Timed Hop	0%	100%
Triple Jump for Distance	7.14%	92.86%
Medicine Ball Chest Pass	0%	100%
2. Do you think Agility testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	64.29%	35.71%
3. Regardless of your answer to Question 2, if Agility tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
T-Test	78.57%	21.43%
505 Agility Test	14.29%	85.71%
5-10-5 (Pro Agility) Test	14.29%	85.71%
Edgren Side-Step Test	7.14%	92.86%
Slalom Test	71.43%	28.57%
Hurdle Test	14.29%	85.71%
Illinois Agility Test	35.71%	64.29%
Zig-Zag Run Test	42.86%	57.14%
Balsom Run	28.57%	71.43%
Arrowhead Agility	28.57%	71.43%
Compass Agility Drill	21.43%	78.57%
4. Do you think Anaerobic Fitness testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	42.86%	57.14%
5. Regardless of your answer to Question 4, if Anaerobic Fitness tests were to be included which of		

the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
300 Shuttle Run	42.86%	57.14%
Running Based Anaerobic Sprint Test.	35.71%	64.29%
Squat Jump Test	57.14%	42.86%
Plyometric Leap Test	28.57%	71.43%
Sprint Fatigue Test	42.86%	57.14%
6. Do you think Aerobic Fitness testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	28.57%	71.43%
7. Regardless of your answer to Question 6, if Aerobic Fitness tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Chester Step Test	0%	100%
20m Shuttle Run (Multi-stage Fitness Test	28.57%	71.43%
Yo-yo Intermittent Recovery Test	71.43%	28.57%
Yo-yo Intermittent Endurance Test	35.71%	64.29%
12 Minute Run	7.14%	92.86%
Loughborough Intermittent Shuttle Test	14.29%	85.71%
***8. Do you think Muscle Length testing should be included in a Functional Movement Screening Tool for Football?**		
	Yes	**No**
	78.57%	21.43%
***9. Regardless of your answer to Question 8, if Muscle Length tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:**		
	Yes	**No**
Adductor/Groin Flexibility Test	85.71%	14.29%
Lumbar Erector Spinae Assessment	14.29%	85.71%
Quadratus Lumborum Assessment	14.29%	85.71%
Ober's Test (ITB)	42.86%	57.14%
Internal Rotators of the Hip Assessment	78.57%	21.43%
External Rotators of the Hip Assessment	78.57%	21.43%
Kendall's Test	7.14%	92.86%
Thomas Test	28.57%	71.43%
Modified Thomas Test	100%	0%

Piriformis Test	50.00%	50.00%
Gastrocnemius Test	57.14%	42.86%
Soleus Test	50.00%	50.00%
Sit & Reach Test	46.15%	53.85%
10. Do you think Anthropometric testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	50.00%	50.00%
11. Regardless of your answer to Question 10, if Anthropometric tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Height	78.57%	21.43%
Weight	78.57%	21.43%
Body Mass Index	57.14%	42.86%
Body Fat-Skin Callipers	85.71%	14.29%
Thigh Girth	50.00%	50.00%
Calf Girth	50.00%	50.00%
Torso Height	21.43%	78.57%
12. Are there any tests which have not been included on this survey that you feel should be on a Functional Movement Screening Tool for Football? If yes, please list the names of the tests or descriptions of the tests in the box below.		
	Yes	**No**
	64.29%	35.71%
Additional Tests:		

Appendix 10- Results of Online Survey *Phase 1A*-Round 2

Functional Movement Screening for Football (Resutls-Round 2)		
1. Do you think the following test(s) should be included in a Functional Movement Screening Tool for Football? (Please remember to see document in the email for this survey which has descriptions of each test if you are unfamiliar with them)		
	Yes	**No**
Deep Squat	87.50%	12.50%
Single Leg Squat	87.50%	12.50%
Triple Hop for Distance	50.00%	50.00%
In-line Lunge	100%	0%
Trunk Stability Push Up	62.50%	37.50%
Star Excursion Balance Test	12.50%	87.50%
Y-Balance Test	75.00%	25.00%
Multiple Single-leg Hop Stabilisation test	37.50%	62.50%
Rotational Stability (Prone Kneeling)	12.50%	62.50%
Vertical Jump Test	87.50%	12.50%
Lateral Lunge Test	25.00%	75.00%
Supine Bridge	37.50%	62.50%
Single-leg Supine Bridge	50.00%	50.00%
Step Down	62.50%	37.50%
Hurdle Step	50.00%	50.00%
Endurance of Lateral Flexors (Side Plank)	25.00%	75.00%
Active Straight Leg Raise	62.50%	37.50%
Single-leg Hop for Distance	37.50%	62.50%
Dorsiflexion Lunge	62.50%	37.50%
2. Do you think Agility testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	37.50%	62.50%
3. Regardless of your answer to Question 2, if Agility tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
T-Test	75.00%	25.00%
Slalom Test	62.50%	37.50%
4. Do you think Muscle Length testing should be included in a Functional Movement Screening Tool for Football?		

	Yes	No
	75.00%	25.00%
5. Regardless of your answer to Question 8, if Muscle Length tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Adductor/Groin Flexibility Test	87.50%	12.50%
Internal Rotators of the Hip Assessment	87.50%	12.50%
External Rotators of the Hip Assessment	87.50%	12.50%
Modified Thomas Test	100%	0%
Piriformis Test	75.00%	25.00%
Gastrocnemius Test	75.00%	25.00%
Soleus Test	75.00%	25.00%
6. Do you think Anthropometric testing should be included in a Functional Movement Screening Tool for Football?		
	Yes	**No**
	62.50%	37.50%
7. Regardless of your answer to Question 10, if Anthropometric tests were to be included which of the following would you select for the Functional Movement Screening Tool for Football:		
	Yes	**No**
Height	75.00%	25.00%
Weight	87.50%	12.50%
Body Mass Index	62.50%	37.50%
Body Fat-Skin Callipers	100%	0%
Thigh Girth	62.50%	37.50%
Calf Girth	62.50%	37.50%

Appendix 11- Online Discussion Board Results

Functional Movement Screening in Football Discussion Board *Phase 1B*
Single-Leg Squat
Author: Erin **Post Subject: Single-Leg Squat**
Single Leg Squat Purpose To assess lower extremity functional strength, neuromuscular control and dynamic stability via a single leg. Procedure 1. Have the client stand in single-leg stance on the leg to be assessed 2. Preferable ask the client to perform the test without shoes on so that you can monitor foot biomechanics 3. Instruct the client to keep the trunk and upper body as upright as possible during the squat 4. Instruct the client to place bilateral hand on hips 5. Instruct the client to squat down as far as possible toward the floor, bending at the hip, knee, and ankle as far as necessary **Correct Execution:** Torso remains upright. Knee in line with the foot (second/third toe) or specific criteria... Hip Flexion-65 degrees or greater achieved. Hip Abduction/Adduction less than 10 degrees. Knee Flexion-60 degrees or greater achieved. Knee valgus/varus less than 10 degrees. (Liebenson 2002; Livengood et al 2004; Bailey et al, 2010)
Author: Participant 1 **Post Subject: Single-Leg Squat**
Think you need some set criteria. Agree with the ones you have suggested, the only one I would add to this would be the translation of the knee over the foot. Not sure if applicable, but we found that high and low threshold single leg squat did vary performance Some could perform a perfect SLSq slowly but when hopping the mechanics were terrible!
Author: Erin **Post Subject: Single-Leg Squat**
Although I like the idea of a SLSq with a hop, this test was not selected by the majority of the group, therefore it has not been included. Anyone else's thoughts on set criteria?
Author: Participant 3 **Post Subject: Single-Leg Squat**
I think the Single leg squat is a great test, although the difficulty is being able to get an objective measure. In terms of the actual testing protocol I think the first testing procedure you mention is the better of the two, without specific criteria. What are the suggestions for a marking criteria? Subjective? Objective?
Author: Erin **Post Subject: Single-Leg Squat**
Thanks Participant 3. The scoring of the test will be discussed once procedural operations have been defined. Therefore we could use the following procedure: Procedure 1. Have the client stand in single-leg stance on the leg to be assessed 2. Preferable ask the client to perform the test without shoes on so that you can monitor foot biomechanics 3. Instruct the client to keep the trunk and upper body as upright as possible during the squat 4. Instruct the client to place bilateral hand on hips 5. Instruct the client to squat down as far as possible toward the floor, bending at the hip, knee, and ankle as far as necessary Then the marking criteria will be based on set criteria. Is everyone happy with this procedure? Do we need to state any specific instructions regarding knee placement over the foot in the definition?

Functional Movement Screening in Football Discussion Board *Phase 1B*

In-Line Lunge

Author: Erin
Post Subject: In-Line Lunge

In-Line Lunge

Purpose
The test is aimed at placing the body in a position that will focus on the stresses incurred during rotational, decelerating and lateral-type movements. The test is used to assess hip mobility and stability, as well as ankle and knee stability.

Procedure
1. Measure the client's tibial length with a tape measure.
2. Have the client place one foot on a pre-marked line.
3. Mark the distance of the client's tibial length on the line from the client's back toe
4. Place a rod/dowel/stick behind the client's back, touching the head, thoracic spine and sacrum.
5. Instruct the client to grasp the top of the dowel with the hand ipsilateral to the back of the foot.
6. Ask the client to take a step and place the front of the heel on the mark.
7. Ensure the client's feet are on the same line and pointing straight ahead throughout the assessment.
8. Have the client perform the lunge up to 3 times in a slow controlled manner.

Correct Execution:
Torso remains upright and still.
Feet remain in a saggital lane and on the line.
Knee touches behind heel of the front foot.

Adapted from Cook et al, 1998

Author: Participant 1
Post Subject: In-Line Lunge

How strict you are on the grading of this test has been our issues, Cook talks about any lack of alignment (rear foot not quite straight enough etc..) would lead to a 2/3
The issues come with how much coaching and teaching you give and once again the intratester reliability.
I think the easiest thing to do would be to stick to the FMS testing manual to keep it is standardised as possible - I know Gray and Kyle have gone to a lot of trouble to try and validate their testing and ensure all examiners are trained
IS this too much for your functional testing ?

Author: Erin
Post Subject: In-Line Lunge

Functional Movement Screening in Football Discussion Board *Phase 1B*

Deep Squat

Author: Erin
Post Subject: Deep Squat

Deep Squat

Purpose
The squat is a movement needed in most athletic events. It is the ready position and is required for most power movements involving the lower extremities. The deep squat is a test that challenges total body mechanics when performed properly. The deep squat is used to assess bilateral, symmetrical, functional mobility of the hips, knees, and ankles. A (rod/dowel/stick) may be held overhead to assesses bilateral, symmetrical mobility of the shoulders as well as the thoracic spine.

Procedure
1. The individual assumes the starting position by placing his/her feet approximately shoulder width apart and the feet aligned in the sagittal plane.
2. The individual then adjusts their hands on the rod/dowel/stick to assume a 90-degree angle of the elbows with the dowel overhead.
3. Next, the rod/dowel/stick is pressed overhead with the shoulders flexed and abducted, and the elbows extended.
4. The individual is then instructed to descend slowly into a squat position. The squat position should be assumed with the heels on the floor, head and chest facing forward, and the rod/dowel/stick maximally pressed overhead.
5. As many as three repetitions may be performed.

Correct Execution:
Upper torso parallel with tibia or toward vertical.
Femurs below horizontal.
Knees aligned over feet.
Rod/Dowel/Stick (arms) aligned over feet.

(Cook et al 1998; NASM,2010) *NB This test can be performed without a rod/dowel/stick. The arms can just be placed overhead if the group decides this is more appropriate.
Author: Erin **Post Subject: Deep Squat**
I think we are so familiar with this test, the definition has not been reviewed. Any comments please?
Author: Participant 1 **Post Subject: Deep Squat**
Think it has good validation and research behind it, just need to ensure the parameters are being followed by the examiner

<u>Functional Movement Screening in Football Discussion Board *Phase 1B*</u>
<u>Y-Balance Test</u>
Author: Erin **Post Subject: Y-Balance Test**
<u>Y-Balance Test (modified)</u> Purpose To measuring pre and post rehabilitation performance, improvement after performance enhancement programs, dynamic balance and return to sport readiness. Procedure (The procedure has been modified as some clubs may not have the Y-Balance test kit) 1. Using tape a Y Balance set up is marked out. A centre box is marked with three lines coming off of it-Anterior Line, Posterolateral Line & Posteromedial Line. 2. The athlete stands with hands on hips and both legs on the ground with the centre of one foot placed in the centre of the axis (centre of foot equates to 2nd toe and middle of medial border of foot) and the other foot is placed beside it. 3. Three practice trials are undertaken on each leg in each direction. 4. Recording: Player is instructed to ‘reach as far as possible along each line’ 5. The furthest distance reached is recorded. 6. A recovery of 10 seconds is taken between each test with 3 tests undertaken in each position on each leg. 7. The test is considered invalid if the hands are removed from the hips, the leg does not return to the start position, the reach foot is placed on the ground either side of the line or if the athlete raises or moves the stance foot during the test. Correct Execution: The furthest reach distance is recorded for each direction on each leg. Normative data needed for this test (or to be decided by the group). *Centre box dimensions and line placement also to be discussed.
Author: Participant 1 **Post Subject: Y-Balance Test**
Our biggest issue with this test is the familiarisation period. Players learn very quickly so this becomes an issue as when to stop trials. Other than that the Y balance has a good, reliable and valid testing procedure. (test takes a good 10min + per player we have found)
Author: Erin **Post Subject: Y-Balance Test**
Do people think we adapt the protocol (similar to above) so it can be used without the kit or is expected that the y-balance test kit will need to be used for this test? Thoughts???
Author: Participant 3 **Post Subject: Y-Balance Test**
I think that the Y balance kit should be used. It has been designed for purpose and would be ideal.
Author: Erin **Post Subject: Y-Balance Test**
My only concern is by requiring the Y-Balance kit you restrict the tool to only those who have access to the equipment. Does anyone think we can standardise a procedure without the Y-Balance Kit or is it essential for this tool?

Functional Movement Screening in Football Discussion Board *Phase 1B*
Modified Thomas Test
Author: Erin **Post Subject: Modified Thomas Test**
Modified Thomas Test Purpose To determine the extensibility, length and excursion of the hip flexors. Procedure 1. Position the client so that they are supine, with pelvis level and square to the trunk and knees are approximately four inches off the edge of the plinth/table. 2. Have the client flex both hips, bringing their thighs up onto the trunk. 3. Have the client hold one leg to their chest and let his other leg down until it is flat on the table. If the thigh rises off the table, attempt to flex the knee on that side. 4. If the knee flexes easily, the tight hip flexor is the iliopsoas (positive test for iliopsoas). If you are unable to flex the knee, or resistance is felt, the rectus femoris is tight (positive test for rectus femoris). Correct Execution: Testing leg remains flat on testing surface. Testing leg-knee flexion at 90 deg or more. Testing leg off the surface=tight illiopsoas. In ability to bend the knee of the test leg = tight rectus femoris. Peeler and Anderson 2008. *NB Specific goniometric measurements (normative data) found in Physiological Tests for Elite Athletes by the Australian Sports Commission (Gore, 2000). Details not provided for source of this normative data.
Author: Participant 1 **Post Subject: Modified Thomas Test**
Again test retest a nightmare due to standardisation (sorry if I am sounding like a broken record!) My key thoughts on this one would be; Would you look at TFL tightness (if loss of adduction is present - or symptoms ease with abduction) - this is one we are really keen to find out. Also other tests use a pressure cuff in the lower back to standardise position - personally I feel this is too much and ensuring the trunk is still and the knee is at 90 is the best way/ We have used a mulligans belt to stabilise the patient which is relatively quick and easy to do? We also have measure height from plinth instead of angle (or electric goniometer on phone also)
Author: Erin **Post Subject: Modified Thomas Test**
Great comments and ideas. Im with you on this test. Always been a bit of a nightmare in terms of standardising the procedure and measurement. I like the idea of stabilising with a mulligan belt. What are everyone else's thoughts on measuring? Has anyone else used leg to plinth measure previously? Will definitely get digging through the literature as have a feeling I recently found a study that used this measurement technique.
Author: Erin **Post Subject: Modified Thomas Test**
Despite my best efforts I cannot find the piece of work I thought I had seen using the plinth to leg measure. Does anyone have a reference for this method?
Author: Participant 1 **Post Subject: Modified Thomas Test**
If there are no references to this it would probably be best to keep to angle with goniometer. You can measure femur angle and tibia angle for RF but also discuss J sign for the TFL tightness?

Functional Movement Screening in Football Discussion Board *Phase 1B*

Internal Rotators of the Hip Assessment

Author: Erin
Post Subject: Internal Rotators of the Hip Assessment

Muscle Length Test-Internal Rotators of the Hip

Purpose
To determine the extensibility, length and excursion of the internal rotators of the hip.

Procedure
1. Position the client so that they are prone on the testing surface.
2. Passively flex the knee to 90deg.
3. Have the stationary arm of the goniometer running parallel to the testing surface and the moveable arm running parallel to the tibia of the testing limb.
4. Palpate the opposite PSIS and passively externally rotate the limb being tested.
5. Take the measurement when you note rotation of the pelvis.

Correct Execution:
ROM should be symmetrical.
Normative values are unavailable.

Bullock-Saxton & Bullock 1994; Reiman & Manske 2009

Author: Participant 1
Post Subject: Internal Rotators of the Hip Assessment

As with the internal rotation, ensure the trunk is stable and measure the external rotation with electric goniometer on specific landmark on the tibia

Author: Erin
Post Subject: Internal Rotators of the Hip Assessment

At last a test that is not as complicated. How do others feel about using a goniometer? Electric goniometer? Inclinometer?

Author: Erin
Post Subject: Internal Rotators of the Hip Assessment

As with external rotator length, is everyone happy to allow therapist choice here regarding goniometer? If available electric goniometer, if not a normal goniometer may be used?

Author: Participant 1
Post Subject: Internal Rotators of the Hip Assessment

Goniometer fine, all about stabilisation for me

Functional Movement Screening in Football Discussion Board *Phase 1B*

Vertical Jump

Author: Erin
Post Subject: Vertical Jump

Vertical Jump Test

Purpose
To assess the client's explosive power in a vertical direction.

Procedure
1. Position the client so that they are standing with equal weight on bilateral lower extremities which are approximately shoulder width apart.
2. Have the client push back the highest reachable marker on a Vertec or make a mark on a wall with chalk.
3. Record the mark as the zero starting position.
4. For the jump, choose the hand position you prefer (hips/behind back/free) and keep this consistent.
5. Instruct the client not to move the feet and to flex at the knee, hip and ankle; jump and push back the highest reachable marker on the Vertec or to make a mark on the wall.
6. Record the distance.

Correct Execution:

Vertical jump height mean has been reported to be between 40-60cm. Specific football reference is desired here.
*NB Group needs to discuss method of measuring vertical jump height (Vertec/Chalk/Jump mat)

Author: Participant 1
Post Subject: Vertical Jump

think jump matt is necessary, and standardisation of hand position is essential

We have the following protocols for all our jump tests (if this helps ??)

Squat jump - without arms
1. The player should step onto the jump-mat and place both their hands on their hips.
2. Instruct the player to assume a squatting position, with their knees flexed at approximately 90º of knee flexion.
3. Following a standardised countdown (i.e., 2, 1, jump), the players should jump as high as possible, landing on the jump-mat with a cushioned landing.
4. The players should be reminded not to 'flick' their heels as they jump as this may impair their performance.
5. Three attempts should be performed and a minimum of 2 min recovery should be allowed between maximal efforts.
6. Performance in the jumps is measured as the vertical distance jumped and the highest measurement should be used for analysis.

Countermovement jump - without arms
1. The player should step onto the jump-mat and place both their hands on their hips.
2. Following a standardised countdown (i.e., 2, 1, jump), the players should jump as high as possible, landing on the jump-mat with a cushioned landing.
3. The players should be reminded not to 'flick' their heels as they jump as this may impair their performance.
4. Three attempts should be performed and a minimum of 2 min recovery should be allowed between maximal efforts.
5. Performance in the jumps is measured as the vertical distance jumped and the highest measurement should be used for analysis.

Countermovement jump - with arms
1. The player should step onto the jump-mat and assume a standardised position with their arms by their side and elbows flexed at 90.
2. Following a standardised countdown (i.e., 2, 1, jump), using their arms to generate momentum, the player should jump as high as possible, landing on the jump-mat with a cushioned landing.
3. The player should be reminded not to 'flick' their heels as they jump as this may impair their performance.
4. Three attempts should be performed and a minimum of 2 min recovery should be allowed between maximal efforts.
5. Performance in the jumps is measured as the vertical distance jumped and the highest measurement should be used for analysis.

Author: Erin
Post Subject: Vertical Jump

Thanks for the info. Very useful. What do the other participant think about using a jump mat? Also, any thoughts on countermovement jump v squat jump; arm swing v no arm swing?

Author: Participant 3
Post Subject: Vertical Jump

I agree with participant 1 in that a jump test requires a jump mat in order to get a true measure of explosive power. In terms of protocol we currently use the one described by participant 1 also. I think the main issue/measurement outcome should be 'time off the ground'. This can be easily measured with a jump mat. I have always felt that as long as there is a certain landing criteria (ie not landing in a squat position to increase time off the ground), then any arm position/counter movement should be acceptable in order to get the highest jump possible.

Author: Participant 1
Post Subject: Vertical Jump

Therefore is everyone happy with the following to be recorded on a jump mat (arm swing allowed):

Countermovement jump - with arms
1. The player should step onto the jump-mat and assume a standardised position with their arms by their side and elbows flexed at 90.
2. Following a standardised countdown (i.e., 2, 1, jump), using their arms to generate momentum, the player should jump as high as possible, landing on the jump-mat with a cushioned landing.
3. The player should be reminded not to 'flick' their heels as they jump as this may impair their performance.
4. Three attempts should be performed and a minimum of 2 min recovery should be allowed between maximal efforts.
5. Performance in the jumps is measured as the vertical distance jumped and the highest measurement should be used for analysis.

Functional Movement Screening in Football Discussion Board *Phase 1B*

External Rotators of the Hip Assessment

Author: Erin
Post Subject: External Rotators of the Hip Assessment

Muscle Length Test-External Rotators of the Hip

Purpose
To determine the extensibility, length and excursion of the external rotators of the hip.

Procedure
1. Position the client so that they are prone on the testing surface.
2. Passively flex the knee to 90deg.

3. Have the stationary arm of the goniometer running parallel to the testing surface and the moveable arm running parallel to the tibia of the testing limb.
4. Palpate the opposite PSIS and passively internally rotate the limb being tested.
5. Take the measurement when you note rotation of the pelvis.

Correct Execution:
ROM should be symmetrical.
Normative values are unavailable.

Bullock-Saxton & Bullock 1994; Reiman & Manske 2009

Author: Participant 1
Post Subject: External Rotators of the Hip Assessment

nice test - I would again standardise the trunk (mulligans belt to plinth) and use the electric goniometer.

Author: Erin
Post Subject: External Rotators of the Hip Assessment

I agree, stabilisation is key. Again..how do others feel about using a goniometer? electric goniometer? inclinometer?

Author: Erin
Post Subject: External Rotators of the Hip Assessment

Is everyone happy to allow therapist choice here regarding goniometer? If available electric goniometer, if not a normal goniometer may be used?

Functional Movement Screening in Football Discussion Board *Phase 1B*

Adductor/Groin Flexibility Test

Author: Erin
Post Subject: Adductor/Groin Flexibility Test

Adductor/Groin Flexibility Test

Purpose
To measure the flexibility in the adductor muscles.

Procedure
1. Ask the athlete to sit on the floor with their knees bent, their feet flat on the floor and legs together.
2. Ask the athlete to let their knees drop sideways as far as possible keeping the feet together. The soles of the feet should be together and facing each other.
3. Have the athlete hold on to their feet with both hands, and pull the ankles as close to the body as possible.
4. Measure the distance from the heels to the groin.

or.....

1. Athlete lies supine with both knees flexed to 90 degrees and both hips at 45 degrees of flexion with feet touching each other.
2. Let the knees drop downward so that the soles of the feet may be touching (hips now externally rotated and abducted).
3. Measure the distance from the head of fibula to the testing surface on both sides.

or...

1. Athlete lies supine with legs straight out on the testing surface.
2. Align the moving arm of the goniometer to the long axis of the femur, the stationary arm parallel to a line between the ASISs.
3. Passively move the testing leg away from the midline until femoral rotation occurs, indicating the end of the adductor flexibility.

Correct Execution:
*This will depend on testing method. Correct execution to be discussed once procedure has been standardised.

Author: Participant 1
Post Subject: Adductor/Groin Flexibility Test

test 1 - difficult as it would be effected by limited knee flexion
test 2 -will be effected by hip mobility (is a modified fabers test)
test 3 - better for adductors but the trunk will need to be fixed to avoid side flexion at the lumbar spine

Author: Participant 3
Post Subject: Adductor/Groin Flexibility Test

Agree - Tests 1 and 2 are flawed in terms of Hip/Knee ROM and not specific enough to the adductors. Test 3 is certainly the better of the three options although I think we will all agree that someone may be able to unilaterally abduct one hip well, but be unable to abduct both hips at the same time well. Therefore do we not need to record a Bilateral Abduction score in the supine position as well?

There are of course other issues such as a person’s range of abduction in a flexed/extended/combined position rather than neutral. Should we again therefore not be looking to assess 'muscle length' in combination with the functional tests?

Author: Erin

Post Subject: Adductor/Groin Flexibility Test

Sounds like option 3 is preferred for this test. Participant 3-you mention assessing adductor length alongside functional tests. Can you expand on what you had in mind here?

Author: Participant 3
Post Subject: Adductor/Groin Flexibility Test

Yes - This could probably be achieved by something as simple as a lateral/split lunge. I feel we often perform functional adductor lengthening/eccentric work as a rehab/treatment tool - but very rarely do we assess the adductors in such a way. I dont have any specific test at present that I would suggest, but certainly feel that it is something that could be developed.

Author: Erin
Post Subject: Adductor/Groin Flexibility Test

A lateral split is an option. Anyone else in the group have any thoughts on this test?

Author: Erin
Post Subject: Adductor/Groin Flexibility Test

I think the problem with muscle length testing is most are not functional. I was surprised by their inclusion in the tool although I can see the relevance. A lateral split lunge may be more functional but is harder to standardise. Does anyone have a protocol for a split lunge? Or would the group prefer to stick with the non-functional standardised procedure below:

1. Athlete lies supine with legs straight out on the testing surface.
2. Align the moving arm of the goniometer to the long axis of the femur, the stationary arm parallel to a line between the ASISs.
3. Passively move the testing leg away from the midline until femoral rotation occurs, indicating the end of the adductor flexibility.

Author: Participant 1
Post Subject: Adductor/Groin Flexibility Test

agreed - best way to do it, but ensure the trunk is stable with MWM belt if needed

<u>Functional Movement Screening in Football Discussion Board *Phase 1B*</u>

<u>**Gastrocnemius Test**</u>

Author: Erin
Post Subject: Gastrocnemius Test

<u>**Muscle Length Test Gastrocnemius**</u>

Purpose
To determine the extensibility, length and excursion of the gastrocnemius.

Procedure
1. Position the client so that they are his supine with the hip and knee extended.
2. Maintaining full extension of the knee perform passive dorsiflexion of the ankle.
3. Palpate the following landmarks and align the goniometer accordingly: stationary arm at the head of the fibula, the axis at the lateral malleolus and the moving arm is parallel to the fifth metatarsal.
4. Ensure that the knee remains in full extension during dorsiflexion.
5. Maintain subtalar neutral; this is thought to allow for pure dorsiflexion by avoiding pronation & supination.
6. Use the goniometric measurement as the score.

Correct Execution:
Normal range of motion with knee extended = 10 degrees of dorsiflexion.

(Wang et al 1993; Reece & Bandy 2002; Kendall, et al 2005; Reiman & Manske 2009)

*NB Gastrocnemius muscle length test can also be performed in weight-bearing if the group feels this would be more appropriate.

Author: Participant 1
Post Subject: Gastrocnemius Test

Understand why you think there is a strong need to do the test in NWB and control sub talor position, however the intratester reliability of controling that variable and also then the intratester reliability of the goniometer starts to make the reliability of the test re test weak.
Personall a lunge (WB DF/ knee to wall) for soleus or a rear foot straight leg lunge are easier tests, if lacking true control of the STJ. As long as you try to control the movement in sagital plane (keep the knee over the 2nd toe for instance) I feel that the ease of test and greater test retest outways the issues of NWB and controlling of STJ.
IF this is going to be for a functional movement screen carried out on high numbers in a short time on a 6 monthly basis the key to it all is ease of testing and repeatability of testing.

Author: Erin
Post Subject: Gastrocnemius Test

Great comments here. I encourage everyone to speak their mind. I do not have any strong preferences on this test being weight-bearing or non-weight bearing. Personally I agree that weight-bearing lunge is more functional. The opening definitions you see on each test have been taken from literature to help start conversation. They are not set in stone. That is what Im hoping comes out of this discussion board-participants discuss the most appropriate way of testing and then that definition is brought forward.

Author: Participant 3
Post Subject: Gastrocnemius Test

I completely agree in that the key to success of this screen is repeatability and ease of testing. With that in mind I too have to question the benefit of a NWB gastroc length test, both in terms of test reliability and how, if at all this information would be of benefit.

I think a Functional DF (Knee to wall) test would be far more beneficial and far more measurable. I think in terms of measurements, an objective measure would be useful ie (cm's - distance toe to wall), as well as more importantly comparing left and right.

Author: Participant 3
Post Subject: Gastrocnemius Test

Just to clarify the above I am aware that the DF Knee to wall will not assess Gastroc length, It is more the fact that I question the value of gastroc length as a useful measure, and feel DF range a better/more useful measure.

Author: Erin
Post Subject: Gastrocnemius Test

Excellent points. I agree weight bearing is more functional. A number of text books have cited this method for measuring gastroc length, however the protocols are very limited. I will aim to post a new protocol in the next few days. I want to consult a few articles as well as text for standardisation.

Author: Erin
Post Subject: Gastrocnemius Test

Again it was hard to find a standardised weight-bearing method for measuring gastrocnemius length. The following was the only one found which attempted to standardise the protocol.
1. The participant placed both hands on a wall in front of them.
2. They positioned their right leg behind the left leg as far as possible ensuring the right knee was fully extended.
3. The right foot was positioned parallel to a tape-line on the floor, which was orientated perpendicular to the wall.
4. The second toe and the centre of the heel were placed directly over the tape-line in order to attempt to reduce the subtalar joint from pronating during the measurement procedure and therefore falsely elevating the value of ankle joint dorsiflexion.
5. The participant then leaned forward until maximum stretch was felt in the right posterior leg, while keeping the right knee fully extended and the right heel in contact with the ground.
6. The left leg remained in a comfortable position to maintain balance and not to restrict dorsiflexion of the right ankle.
7. The angle the right tibia made to the vertical was then measured using a digital inclinometer/ goniometer.

Munteanu et al (2009)
Thoughts on the test?

Author: Erin
Post Subject: Gastrocnemius Test

As with Soleus, Please comment on two things:

1) updated functional length measure procedure
2) if we are measuring other muscle lengths in non-functional positions, do we still feel functional length is the best measure here?

Functional Movement Screening in Football Discussion Board *Phase 1B*

Piriformis Test

Author: Erin
Post Subject: Piriformis Test

Muscle Length Test-Piriformis

Purpose
To determine the extensibility, length and excursion of the piriformis.

Procedure
1. Position the client so that they are supine on a stable testing surface with bilateral lower extremities extended.
2. Passively flex the hip to 90deg then adduct and internally rotate to the end range of the movement.
3. Normal length allows the hip to flex to 90deg, adduct 20deg and internally rotate to 20deg.

Correct Execution:
Hip to flex to 90deg, adduct 20deg and internally rotate to 20deg.

(Kendall et al 2005; Kroon & Kruchowsky 2006)

Author: Participant 1
Post Subject: Piriformis Test

What will be your determining variable ? Flexion adduction or internal rotation ? or are you just going to grade the player as to whether they can hit this target?
With 3 variables this makes it more complex and less reliable. if you standardise the flexion and adduction then measure the internal rotation this might be easier ? (would have to go back to the anatomy to ensure that this is measure piriformis excursion though)

Author: Erin
Post Subject: Piriformis Test

This test has proven difficult to find in the literature. I could only find two protocols for measuring piriformis length and this was the least complicated of the two. Its something I routinely assess in practice however, Ive never really used a specific

test/outcome measure for the test. Im open to suggestions here. I like the idea of fixing flexion and adduction as mentioned and using internal rotation as the outcome measure. Thoughts from anyone else??
Author: Participant 3 **Post Subject: Piriformis Test**
Again I think Piriformis testing will prove extremely difficult in terms of reliability. At a range of more than 90 degrees the actions of the piriformis are reversed to adduct and internally rotate. I would therefore (at 90 degrees of flexion) tend to assess in flexion/abduction and external Rotation - however as mentioned this will be almost impossible to measure. The other issue with testing using the originally mentioned method is that it has the potential to bring on 'Hip Impingement', especially in the footballer population. Obviously we have chosen Piriformis length to be included in the screen but I wonder what other peoples thoughts are on how much value it will be in view of the difficulty in assessing?
Author: Erin **Post Subject: Piriformis Test**
This testing is proving to be quite a challenge. I have double checked the literature and Kendall et al (2005) and Kroon & Kruchowsky (2006) both state that for piriformis length testing the leg should be placed in 90deg of hip flexion, 20 deg of hip adduction and hip internal rotation. I agree that when you anatomically consider piriformis function at hip flexion (ext rotation & abduction) you would think it would be hip flexion, adduction and external rotation. This is not what is in the literature. Other pieces of work have simply said to assess it alongside the hip external rotators (not in isolation) by using prone position, knee at 90deg of flexion and internally rotating the hip. This test has also been included already in this tool. Thoughts from the group?
Author: Erin **Post Subject: Piriformis Test**
Please comment on which test you would prefer to use to assess piriformis length taking into consideration the variation in the literature as mentioned above.

<u>Functional Movement Screening in Football Discussion Board *Phase 1B*</u>
<u>Soleus Test</u>
Author: Erin **Post Subject: Soleus Test**
<u>Soleus Test</u> Purpose To determine the extensibility, length and excursion of the soleus. Procedure 1. Position the client so that they are supine with the hip and knee flexed to 45deg. 2. Place the opposite lower extremity on the support surface with the knee extended. 3. Maintaining the hip and knee flexion of 45deg perform passive dorsiflexion of the ankle. 4. Palpate the following landmarks and align the goniometer accordingly: stationary arm at the head of the fibula, the axis at the lateral malleolus and the moving arm is parallel to the fifth metatarsal. 5. Maintain subtalar neutral; this is thought to allow for pure dorsiflexion by avoiding pronation & supination. 6. Use the goniometric measurement as the score. 7. The test can also be measured in prone position with the knee bent to 90deg. **<u>Correct Execution:</u>** Normal range of motion with knee flexed = 20 degrees of dorsiflexion. (Wang et al 1993; Reece & Bandy 2002; Kendall, et al 2005; Reiman & Manske 2009) *NB Soleus muscle length test can also be performed in weight-bearing if the group feels this would be more appropriate.
Author: Participant 3 **Post Subject: Soleus Test**
Again, in terms of reliability and repeatability of testing I think that this test would be extremely difficult and of minimal value, and should be performed in WB as a DF Knee to Wall Test
Author: Erin **Post Subject: Soleus Test**
As per gastroc length, new test instructions to be posted for weight-bearing procedure
Author: Participant 3 **Post Subject: Soleus Test**
Instructions below for Dorsiflexion lunge test (soleus length). Sorry for the delay in posting. Project supervisors were contacted as theoretically this test was not included by therapist during the questionnaire phase of data collection. It was agreed as it is a measure of soleus length, and could still be included by request of the consensus panel. **<u>Dorsiflexion Lunge Test</u>** Purpose To measure functional ankle dorsiflexion in a weight bearing position. Procedure 1. The athlete stands against wall with about 10cm between feet and wall.

2. They move one foot back a foot’s distance behind the other.
3. They bend the front knee until it touches the wall (keeping the heel on ground).
4. If knee cannot touch wall without heel coming off ground, move foot closer to wall then repeat.
5. If knee can touch wall without heel coming off ground, move foot further away from wall then repeat.
6. Keep repeating step 5 until can just touch knee to wall and heel stays on ground.
7. Measure either: a) Distance between wall and big toe (<9-10cm is considered restricted) or b) The angle made by anterior tibia/shin to vertical (<35-38 degrees is considered restricted)
8. Change the front foot and test the other side (symmetry is ideal)

Please comment on two things:
1) updated functional length measure procedure
2) if we are measuring other muscle lengths in non-functional positions, do we still feel functional length is the best measure here?

<u>Functional Movement Screening in Football Discussion Board *Phase 1B*</u>

<u>Initial Scoring Discussion</u>

Author: Erin
Post Subject: Initial Scoring Discussion

This section will continue to develop new topics as decisions are made. The initial discussion is around the way in which the group feels the 12 tests should be scored. There are a number of different ways and the specifics of each method can be discussed and decided as the conversation evolves. Initially I am asking you to comment on the following:

*Do you think each test should be scored individually? This will involve defining individual criterion points for each test. This is similar to Cook et al's (1998) FMS work. ie, Deep Squat Score 0=Pain during testing; 1=Board placed under heels, tibia & torso not parallel (etc) 2=Board placed under heels, upper torso parallel with tibia (etc) 3=Feet flat; Upper torso parallel with tibia

*Do you think there should be a common scoring system for the two distinct sections (Functional Testing & Muscle Length Testing)? This will involve a scale which will give points based on good performance versus incorrect performance. This can be similar to classifying criteria as good, fair or poor; or it can classify movement as achieved as to procedure, achieved with compensation, unable to achieve even with compensation. This can still involve a numeric scoring system.

*Do you think it is possible to establish a common scoring system that can be applied to all tests? This again will be based around classifying a test as good, fair or poor-although numeric values can still be applied to the scoring system if desired.

Author: Participant 1
Post Subject: Initial Scoring Discussion

Functional movements tests should be scored similar to how Cook and Burton suggested. Pain should be recognised and it should be simple, with the parameters clearly set
The Performance matrix (Mottram & Comerford) is a good group of tests with great reasoning, but logistically it falls down with difficulty in testing and the intertester reliability.

the lengths tests need to be standardised to the highest standards to ensure that the joint being moved is the only one and test re test is reliable. I would then measure with an electrical goniometer or ipod type accelerometer devise to ensure the reading is accurate. The reason for measuring the range rather than categorising poor average good is that this measure will change on a daily and weekly basis Less than the functional tests. so it needs to be sensitive to change.

Once we have large amounts of data from all positions / standards / injury prone patients / etc.. only then can we really work out what ranges are good / average / poor.

Author: Erin
Post Subject: Initial Scoring Discussion

Great discussion opener. In particular around the muscle length tests. How does the group feel about using an electrical goniometer or an accelerometer? Are these devices available to the primary users of the screening tool? Does the group feel there is enough evidence to support the reliability & accuracy of electrical goniometers & accelerometers?

Author: Participant 3
Post Subject: Initial Scoring Discussion

I feel that the key to the Functional Movement Screen is exactly that, it is a Screening tool, and not an assessment tool. The benefit being that it is simple to carry out, whilst being able to highlight those players considered 'at risk' and who then need further 'assessment'.

Therefore with this in mind I think if we are looking at a football specific screening tool, we need to keep the scoring system as simple as possible, and not get carried away with exact measurements/assessment.

Appendix 12- Opening Email *Phase 2*

Dear………………..

I am writing to invite you to participate in a **Doctoral study on Functional Movement Screening in Football**. As a Chartered Physiotherapist **your experience is crucial** in order to further the research in this area.

This study aims to develop a Functional Movement Screening Tool that is specifically designed for use in football. The study has been broken down into two Phases. Phase 1 has already been completed. This phase involved a group of Physiotherapists selecting a battery of tests which they felt should be included in a Functional Movement Screening Tool for Football. You are now being asked to participate in Phase 2 of this study. Phase 2 aims to evaluate the tests that have been selected to be included in the screening tool.

If you are a Chartered Physiotherapists and willing to participate in an online questionnaire, I would like to invite you to participate in the study.

Participation in Phase 2 of this study will require you to:

- Complete an online questionnaire (http://www.surveymonkey.com/s/fmstfootball) that should take no longer than 10 minutes.
- The questionnaire will ask you to rank individual tests that have been selected in Phase 1 to be included into a functional movement screening tool for football.

The study will be conducted by myself, Erin Morehead (MSc Sports Med; BSc (Hons) Physio) and supervised by Professor Jim Richards & Professor James Selfe of The University of Central Lancashire. I have spent over 6 years working in professional sport, 5 of which have been in football at both club and national level.

All data collected, other than for direct communication purposes to each participant from myself, will remain anonymous throughout the study. No personal identifiable information will be collected on the questionnaire.

Thank you for considering participation in the study. If you have any further questions, please do not hesitate to contact me. If there is more than one Physiotherapist working at your club, I would be grateful if you could please send me a contact email address for them, so I can invite them to participate in the study or simply forward them this email.

Please see attached information sheet for full study details. If you wish to participate, you do not need to reply to this email, simply click on the link below. The online questionnaire will be open until midnight on Friday August 16th, 2013.

http://www.surveymonkey.com/s/fmstfootball

Kind Regards,

Erin Morehead

Appendix 13- Opening Letter *Phase 2*

Dear Physiotherapist

I am writing to invite you to participate in a **Doctoral Study on Functional Movement Screening in Football**. As a Chartered Physiotherapist **your experience is crucial** in order to further the research in this area.

This study aims to develop a Functional Movement Screening Tool that is specifically designed for use in football. The study has been broken down into two Phases. Phase 1 has already been completed. This phase involved a group of Physiotherapists selecting a battery of tests which they felt should be included in a Functional Movement Screening Tool for Football. You are now being asked to participate in Phase 2 of this study. Phase 2 aims to evaluate the tests that have been selected to be included in the screening tool.

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The study will be conducted by myself, Erin Morehead (MSc Sports Med; BSc (Hons) Physio) and supervised by Professor Jim Richards & Professor James Selfe of The University of Central Lancashire. I have spent over 6 years working in professional sport, 5 of which have been in football at both club and national level.

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Thank you for considering participation in the study. If you have any further questions, please do not hesitate to contact me. If there is more than one Physiotherapist working at your club, I would be grateful if you could please send me a contact email address for them, so I can invite them to participate in the study or simply pass on this letter to them.

Please see attached information sheet for full study details. If you wish to participate, you do not need to respond to this letter, simply access the link below online. The online questionnaire will now be open until midnight **Friday August 30th, 2013**.

http://www.surveymonkey.com/s/fmstfootball

Kind Regards,

Erin Morehead MSc (Sports Med), BSc (Hons) Physio, MCSP, HPC
Course Leader-BSc Strength & Conditioning (Army Cohorts)
Senior Lecturer in Physiotherapy, Sports Therapy and Strength & Conditioning
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<u>Appendix 14- Information Sheet *Phase 2*</u>

Title of main Professional Doctorate study

Development of a Functional Movement Screening Tool for Football

Aim of this study

This study aims to establish the current clinical practice of Physiotherapists in the UK for functional movement screening techniques of football players.

Objectives of the Professional Doctorate study

Objectives Phase 2

1. To recruit up to 30 Physiotherapists working in non-Premiership football to evaluate the functional movement screening tool developed in Phase 1.
2. To distribute the functional movement screening tool developed in Phase 1 to the recruited group.
3. To gain the views of the recruited group on the functional movement screening tool developed in Phase 1.

Who will conduct the research?

Erin Morehead, MSc Sports Medicine, BSc (Hons) Physiotherapy, will be responsible for the management of the study. Erin Morehead will also be responsible for recruitment and data collection. Erin is an active Physiotherapist who works both as a Senior Lecturer and Senior Physiotherapist. Erin spent 6 years working in professional sport, 5 which were in football at both club and national level. The study will be supervised by Professor Jim Richards and Professor James Selfe.

What we will ask you to do

We are asking you to participate in the second phase of a project on developing a Functional Movement Screening Tool for Football. Your role in the project will be to evaluate a screening tool that has been developed specifically for football. You will be asked to complete a short online questionnaire which ranks the appropriateness of each individual test that has been included in the functional movement screening tool for football. The entire questionnaire should take no longer than 30 minutes to complete.

All data collected, other than for direct communication purposes to each participant from myself, will remain anonymous throughout the study. You are free to withdraw from the study at any time, without providing a reason.

Upon completion of the study the results will be submitted to a peer reviewed journal and national/international conferences. The finding will also be made available to the recruited group.

Eligibility Criteria

The criteria for inclusion for the study are; that you currently do not work in Premiership Football and you are prepared to participate in an online questionnaire.

Are there any risks or benefits?

There are no foreseeable risks to you by completing the questionnaire. There will be no immediate direct benefits for you; however the results may help to develop a functional movement screening tool which is specific to football, which may in the future help your clinical practice.

Data storage

All data will be stored in line with UCLAN regulations. Electronic data will anonymised and stored on password-protected computers. All consent forms and other documents will be stored so that no names can be associated with them in a locked filling cabinet. Electronic data and forms will be kept for 5 years following the end of the project.

Who has approved this study?

This study has been approved by the Faculty of Health Ethics Committee.

Who can I contact to discuss any issues or to make a complaint?

If you wish to discuss any aspect of this project you are welcome to contact Erin Morehead, or if you have any issues with the conduct of the staff taking part in this study you can contact Jim Richards (Director of Studies).

Erin Morehead

University of Central Lancashire

Preston

PR1 2HE

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Tel: 01772 894562

Jim Richards

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Appendix 15- Ethics Approval Letter *Phase 2*

2nd May 2013

Jim Richards & Erin Morehead
School of Sports Tourism & the Outdoors
University of Central Lancashire

Dear Jim & Erin

Re: BuSH Ethics Committee Application
Unique Reference Number: **BuSH 160**

The BuSH ethics committee has granted approval of your proposal application 'Development of a Functional Movement Screening Tool for Football'.

Please note that approval is granted up to the end of project date or for 5 years, whichever is the longer. This is on the assumption that the project does not significantly change, in which case, you should check whether further ethical clearance is required

We shall e-mail you a copy of the end-of-project report form to complete within a month of the anticipated date of project completion you specified on your application form. This should be completed, within 3 months, to complete the ethics governance procedures or, alternatively, an amended end-of-project date forwarded to roffice@uclan.ac.uk quoting your unique reference number.

Yours sincerely

Denise Forshaw
Chair
BuSH Ethics Committee

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.