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PREVENTION OF ANTERIOR CRUCIATE LIGAMENT INJURY WITHIN WOMEN'S FOOTBALL – AN EXERCISE PACKAGE

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The purpose of this thesis was to create an exercise package containing evidence based, research proven exercises for the prevention of anterior cruciate ligament injuries in women's football that can be used by both players and coaches. Injury prevention programs have been shown to reduce the risk of injury in women's football and by combining the exercises into one package it will make them more accessible to the players and coaches.

The thesis was carried out in collaboration with the first team of a local football club that compete in the top division of women's football in Finland, Nice Futis Football Club and feedback was obtained from the players and coaches to establish the most user friendly format for the package. The exercise package was formulated using exercises from recent studies that have shown to reduce injuries when implemented into a training plan. The thesis also explores the factors leading to injury risk and why women are more at risk than their male counterparts.

The use of photos and written explanations in the exercise package allows for maximum learning potential while keeping the package simple to use. The recording of injuries throughout the season also allows for future evaluation of the exercise package and its impact on injury rates. This acts as a motivational tool when players and coaches can see the positive effects of implementing the exercises provided.

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1 INTRODUCTION

There are many reasons and benefits for participating in sports, including, to name but a few, decreased risk of obesity, diabetes and other non-communicable diseases, reduced stress, increased fitness levels, and increased social contact (Website of the NHS 2012). Unfortunately when a physical activity is performed it brings with it the risk of injury.

Football carries a higher risk of injury than many other sports, with the level of injury being over 1000 times higher than that found in industrial occupation classed as high risk (Hawkings & Fuller 1999, 196, 200, 202) and it is responsible in Europe for between a quarter and a half of all sports injuries (Tscholl, O'Riordan, Fuller, Dvorak, Gutzwiller & Junge 2007, 8). Specifically, knee injuries can account for between 20% and 31.8% of these injuries (Ekstrand 2008, 75 & Giza, Mithöfer, Farrell, Zarins & Gill 2005, 212, 213).

Although it has been suggested through numerous studies that the injury rate between men and women is similar, or in some cases less prevalent in men's football (Dvorak & Junge 2000, 4), female players seem to be more susceptible to knee injuries, specifically anterior cruciate ligament tears (Giza, Mithöfer, Farrell, Zarins & Gill 2005, 212). There are many suggested theories of the cause of this, however there is, as of this time, no one singular cause for these injuries.

Due to the high level of knee injury during football it is clear that a suitable injury prevention program would help reduce the number of injuries experienced by players and teams each season. Injury prevention is highly important for every athlete in all sports. It helps to allow the individual to reach their potential while also reducing the risk of long term health problems. Implementing a sports specific injury prevention plan is often an underused tool available to the coaches and players alike.

The thesis has been produced in collaboration with the first team of Nice Futis Football Club. Nice Futis Football Club is a women's football team from Pori who play in at the top level of women's football in Finland, the Naisten Liiga. The club was founded in 1989 and has teams catering for girls aged between eight years old and upwards. They have a total of 140 players licensed at the current time. The first team has been playing in the Naisten Liiga for a total of five seasons and to coincide with the completion of the thesis have guaranteed a sixth straight season in the top flight. The thesis aims to provide the players and coaches of Nice Futis Football Club first team with an evidence based exercise list that they can incorporate into their training schedule. This will help to reduce the risk of injuries among the players at all levels.

2 THE PURPOSE AND AIM OF THE THESIS

The aim of this thesis is to create a usable, relevant and research proven exercise package to help in the prevention of anterior cruciate ligament injuries within female players in the first team of Nice Futis Football Club. An accessible and understandable package that can be used by both players and coaches, will allow individuals to reduce their injury risk, or a coach to affect a team as a whole.

In the theoretical area it will be explained why there is a specific need for this kind of information package within female football. It will also explain the type of exercises to be used and why these types of exercise are more effective than their alternatives. The practical implementation will be a booklet consisting of the selected exercises, utilising both photos and written explanations to enhance the learning potential.

3 THE KNEE JOINT AND THE ROLE OF THE ANTERIOR CRUCIATE LIGAMENT

The knee is the most commonly injured joint in football (Ekstrand 2008, 75; Giza, Mithöfer, Farrell, Zarins & Gill 2005, 213-215). In addition, the knee is the most vulnerable to damage, due mainly to its structural aspects of being a mobile and weight bearing joint, while stability is in direct correlation to the ligaments and muscles surrounding the joint (Tortora & Derrickson 2009, 292).

Goldblatt & Richmond (2003, 172) stated that in order to make an accurate clinical diagnosis and implement an adequate rehabilitation program for injuries, we require a thorough knowledge of the anatomy and biomechanical function of the structures of the knee.

While the knee is the most injured joint, the most severe and most common of the knee injuries is the anterior cruciate ligament tear (Majewski, Habelt, & Steinbruck 2006, 185). Further more, the majority of anterior cruciate ligament tears are a result of non-contact injuries (Kobayashi, Kanamura, Koshida, Miyashita, Okado, Shimizu & Yokoe 2010, 669, 671-672).

In order for the risk factors to be assessed and a suitable prevention program to be implemented we need an understanding of the loading mechanisms on the anterior cruciate ligament and also knowledge of how the non-contact anterior cruciate ligament tears occur (Yu & Garrett 2007, 47).

3.1 Knee anatomy

“The knee joint (tibiofemoral joint) is the largest and most complex joint of the body. It is a modified hinge joint that consists of three joints within a single synovial cavity:

1. Laterally is a tibiofemoral joint, between the lateral condyle of the femur, lateral meniscus, and lateral condyle of the tibia, which is weight bearing.

2. Medially is a second tibiofemoral joint, between the medial condyle of the femur, medial meniscus, and medial condyle of the tibia.

3. An intermediate patellofemoral joint is between the patella and the patella surface of the femur.” (Tortora & Derrickson 2009, 290).

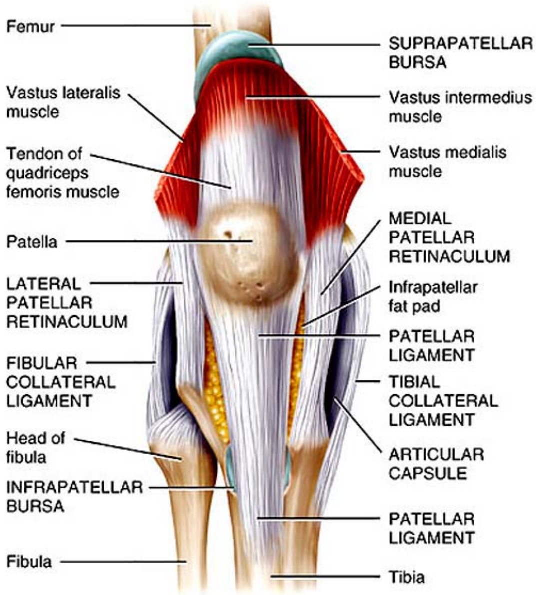

Fig. 1 Anterior superficial view of the knee (Tortora & Derrickson 2009, 291)

Fig. 1 shows an anterior view of the knee joint. The knee joint is surrounded by an “articular capsule” like structure, consisting of a ligamentous sheath made up mostly of muscle tendons. (Tortora & Derrickson 2009, 290) In addition, the knee joint is stabilised by a number of ligaments, these are listed below, with the emphasis on the anterior cruciate ligament due to its importance within the subject of this thesis:

3.1.1 Anterior cruciate ligament

The anterior cruciate ligament “extends posteriorly and laterally from a point anterior to the intercondylar area of the tibia to the posterior part of the medial surface of the lateral condyle of the femur.” (Tortora & Derrickson 2009, 290). It can be divided into two bundles, or bands, the anteromedial and posterolateral bundles. These bundles derive their name from their tibial origins. There is also suggestion that a third intermediate bundle may be present, but there is no conclusive evidence to confirm this at this time. The shorter of the two bundles is the anteromedial band, this band originates at the most proximal part of the femoral origin and inserts onto the anteromedial section of the tibia, these fibres are tense during flexion. The posterolateral bundle has its origins at the distal femoral origin and insert onto the posterolateral section of the tibia, this band works in contrast to the anteromedial bundle as it is lax in flexion and is tensed during extension. (Goldblatt & Richmond 2003, 174 & Zantop, Peterson & Fu 2005, 23). "This functional description of the ACL is somewhat of an oversimplification. The ACL is actually comprised of a continuum of fascicles, each of a different length. Therefore, a different portion of the ligament is taut and functional throughout the range of motion." (Goldblatt & Richmond 2003, 174). The entire anterior cruciate ligament, including both the anteromedial and posterolateral bands, can vary in width size, from 7mm to 12mm (Zantop, Peterson & Fu 2005, 21). Fig. 2 show the anterior cruciate ligament from a deep anterior view.

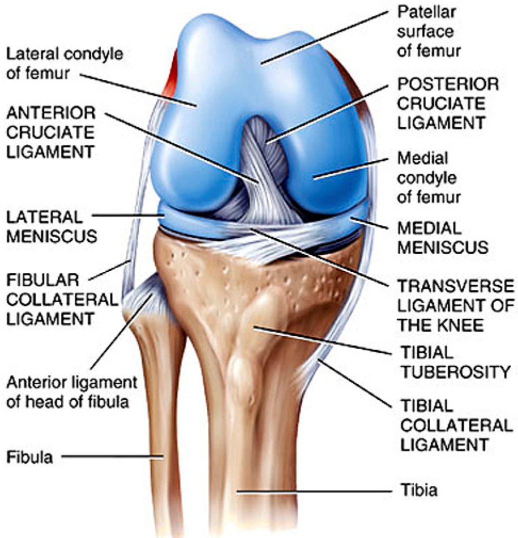

Fig. 2 Anterior deep view of the knee (Tortora & Derrickson 2009, 291)

The tibial nerve innervates the anterior cruciate ligament. Although, the anterior cruciate ligament has been found to have minimal free nerve endings, which has been suggested is the reason that little initial pain is experienced in an anterior cruciate ligament tear. (Goldblatt & Richmond 2003, 174-175). "The nerve supply is postulated to serve a vasomotor function, as well as a possible proprioceptive or sensory function to sense speed, acceleration, position, and direction of motion." (Goldblatt & Richmond 2003, 175).

3.1.2 Posterior cruciate ligament

The posterior cruciate ligament "extends anteriorly and medially from a depression on the posterior intercondylar area of the tibia and lateral meniscus to the anterior part of the lateral surface of the medial condyle of the femur. The PCL prevents the posterior sliding of the tibia (and anterior sliding of the femur) when the knee is flexed. This is very important when walking down stairs or a steep incline." (Tortora & Derrickson 2009, 290). The posterior cruciate ligament can be seen in Fig. 2.

3.1.3 Patellar ligament

The patellar ligament is a "continuation of the common tendon of insertion of the quadriceps femoris muscle that extends from the patella to the tibial tuberosity. This ligament also strengthens the anterior surface of the joint. The posterior surface of the ligament is separated from the synovial membrane of the joint by an infrapatellar fat pad." (Tortora & Derrickson 2009, 290). The patellar ligament can be seen in Fig. 1.

3.1.4 Oblique popliteal ligament

The oblique popliteal ligament is a "broad, flat ligament that extends from the intercondylar fossa of the femur to the head of the tibia and lateral condyle of the femur to the medial condyle of the tibia. The ligament and tendon strengthen the posterior surface of the joint." (Tortora & Derrickson 2009, 290).

3.1.5 Arcuate popliteal ligament

The arcuate popliteal ligament “extends from the lateral condyle of the femur to the styloid process of the head of the fibula. It strengthens the lower lateral part of the posterior surface of the joint.” (Tortora & Derrickson 2009, 290).

3.1.6 Tibial collateral ligament or medial collateral ligament

The tibial or medial collateral ligament is a “broad, flat ligament on the medial surface of the joint extends from the medial condyle of the femur to the medial condyle of the tibia. Tendons of the sartorius, gracilis, and semitendinosus muscles, all of which strengthen the medial aspect of the joint, cross the ligament. Because the tibial collateral ligament is firmly attached to the medial meniscus, tearing of the ligament frequently results in tearing of the meniscus and damage to the anterior cruciate ligament.” (Tortora & Derrickson 2009, 290). It is possible to see the tibial collateral ligament in both Fig. 1 & Fig. 2.

3.1.7 Fibular collateral ligament or lateral collateral ligament

The fibular or lateral collateral ligament is a “strong, rounded ligament on the lateral surface of the joint that extends from the lateral condyle of the femur to the lateral side of the head of the fibula. It strengthens the lateral aspect of the joint. The ligament is covered by the tendon of the biceps femoris muscle.” (Tortora & Derrickson 2009, 290). The fibular collateral ligament can be seen in both Fig. 1 & Fig. 2.

3.2 The role of the anterior cruciate ligament and mechanisms of injury

“The ACL limits hyperextension of the knee (which normally does not occur at this joint) and prevents the anterior sliding of the tibia on the femur. This ligament is stretched or torn in about 70% of all serious knee injuries.” (Tortora & Derrickson 2009, 290).

Goldblatt & Richmond (2003, 175) describe the anterior cruciate ligament as essential to the “controlled, fluid, and stable flexion and rotation of the normal knee.” Furthermore, they stated that the anterior cruciate ligament is the primary restraint of anterior sliding of the tibia in relation to the femur, while also assisting in the restraint of “internal rotation, varus, valgus, and hyperextension.”

When the anterior cruciate ligament is strained to 15% it is at, or close to its maximum stress. Injury is expected when this strain increases from between 15% to 30%. (Goldblatt & Richmond 2003, 175). The anterior cruciate ligament is injured “when an excessive tension force is applied on the ACL.” (Yu & Garrett 2007, 47). Many injury mechanisms have been suggested as possible causes of tears to the anterior cruciate ligament. These include anterior shear force to the proximal end of the tibia, increased peak posterior ground reaction, poor hamstring co-contraction, a reduced angle of knee flexion, and knee valgus movements. (Yu & Garrett 2007, 47-50).

When considering anterior shear force to the proximal end of the tibia, it has been shown that it is a major contributor to anterior cruciate ligament loading. With the quadriceps being the main causation to increasing the anterior shear force and loading the anterior cruciate ligament. The quadriceps causes the most strain on the anterior cruciate ligament between 0°- 45°, with the greatest amount of strain experienced at approximately 35°. (Yu & Garrett 2007, 48).

While the quadriceps muscles are the main contributor to anterior shear force on the anterior cruciate ligament, they also create an increased risk of injury when peak posterior ground reaction is increased. When a posterior ground force reaction is increased the quadriceps muscle contraction is simultaneously increased. While the quadriceps muscles are needed to counteract the flexion created by the posterior ground force, the contraction increases the loading on the anterior cruciate ligament. The implications of these mechanisms means that if a hard landing with a high posterior ground force reaction it could lead to an increased anterior shear force on the anterior cruciate ligament. (Yu & Garrett 2007, 49).

It has long been suggested, that in order to counteract the loading on the anterior cruciate ligament caused by the contraction of the quadriceps, then the hamstring co-contraction should be trained to help protect anterior translation of the tibia in relation to the femur. (Hewett, Lindenfeld, Riccobene & Noyes 1999, 700, 703-704; Yu & Garrett 2007, 49). However, Yu & Garrett (2007, 48-49) referenced numerous studies that dispute this theory. Until the theory is proven or disproven all participants involved in sporting activity should look to maintain muscle balance between all major muscle groups, therefore possibly reducing their risk of injury.

It has been discussed how the quadriceps and hamstrings can have an effect on the loading of the anterior cruciate ligament. In addition to the loading of the anterior cruciate ligament these muscles can also affect the amount of knee flexion available to the athlete. Yu & Garrett (2007, 47-49) observed that an individual is at an increased risk of anterior cruciate ligament injury if they have a smaller knee flexion angle while performing athletic tasks. They also stated that females are more likely to have a smaller knee flexion angle than that of their male counterparts. Furthermore, they show that females over 13 years of age have a reduction in their knee flexion angle during certain tasks, which coincides with an increased rate of anterior cruciate ligament tears. This may explain why females are more susceptible to anterior cruciate ligament injuries and will be discussed in further detail later in the thesis.

Finally, knee valgus movements have been shown to have an impact on anterior cruciate ligament injuries. The most common of the anterior cruciate ligament injuries occur as a result of “knee valgus near full extension with rotation of the tibia and the foot firmly planted on the ground.” (Smith, Ford, Myer, Holleran, Treadway & Hewett 2007, 471). This occurrence would increase anterior shear force while the knee is in a valgus position, and may also be accompanied by a posterior ground force reaction, due to the angle of landing. All of these contributing factors greatly increase the loading on the anterior cruciate ligament and therefore increase the risk of injury. Smith, Ford, Myer, Holleran, Treadway & Hewett (2007, 471) also stated that post pubertal females land from jumps with more knee valgus than that of pre-pubertal females. This suggests that post pubertal women are at a higher risk of injury. However, Yu & Garrett (2007, 49-50) observed that a valgus movement alone is not an indicator for anterior cruciate ligament injury when the medial collateral ligament is intact. Furthermore, they observed that it is the sagittal plane forces that are responsible for anterior cruciate ligament injuries, as without these forces knee valgus movements would not alone cause an injury.

4 FOOTBALL AND ITS FACTORS

Football is the most popular sport in the world, both in terms of spectators and participants. As of 2006 there were at least 270 million people worldwide involved in football on a physical level, 265 million players and 5 million referees and officials. This equates to 4% of the worlds entire population. This number may still not give the full amount of participants due to there being a large amount of unregistered players that grace the game on an occasional basis. (Website of FIFA 2012)

There are many variants to the game of football. It is played by both males and females, from youth to elderly, and able bodied to disabled players. It is also played on different surfaces, including grass, sand, artificial turf, and indoors. All of these factors allow for a highly accessible sport and could play a role in the popularity it exhibits.

Due to the subject of this thesis the type of football described will be the classic 11 v 11, grass (or artificial turf) variant of the game. Football in its most recognizable form is played between two teams of 11 players; each team has a goalkeeper and 10 outfield players that can be arranged into an assortment of formations. The main objective of the game is, by using the feet or head, to score as many goals in the opposition goal, while conceding as few goals as possible in your own goal. During adult full size 11-a-side games the payers will play two halves of 45 minutes each, with a 15 minute half-time break. (Website of FIFA 2012)

The game itself is played on a marked field that can vary in its dimensions. The length of the field must be no shorter than 90 metres (100 yards) and no longer than 120 metres (130 yards). Its width must be a minimum of 45 metres (50 yards) and a maximum of 90 metres (100 yards); it must be noted that even though the minimum length of the field and the maximum width of the field are both 90 metres, the field of play must be rectangular. Fig. 3 shows a regular football field and its marked areas, while Fig. 4 shows the dimensions used for each area. (Website of FIFA 2012)

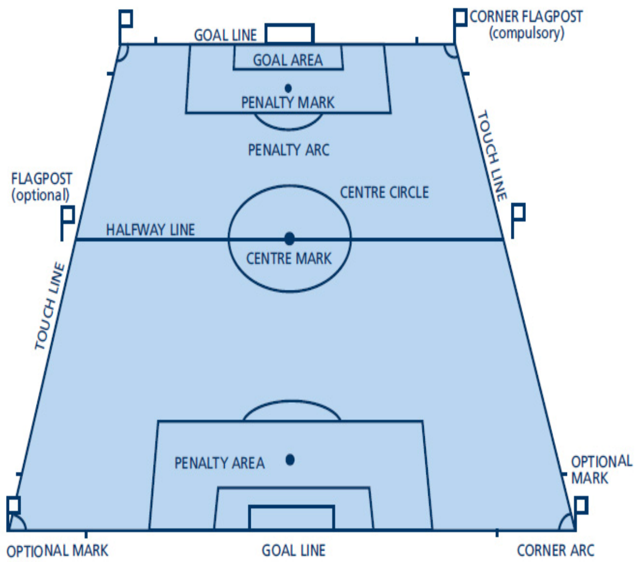

Fig. 3 Areas of a football field (Website of FIFA 2012)

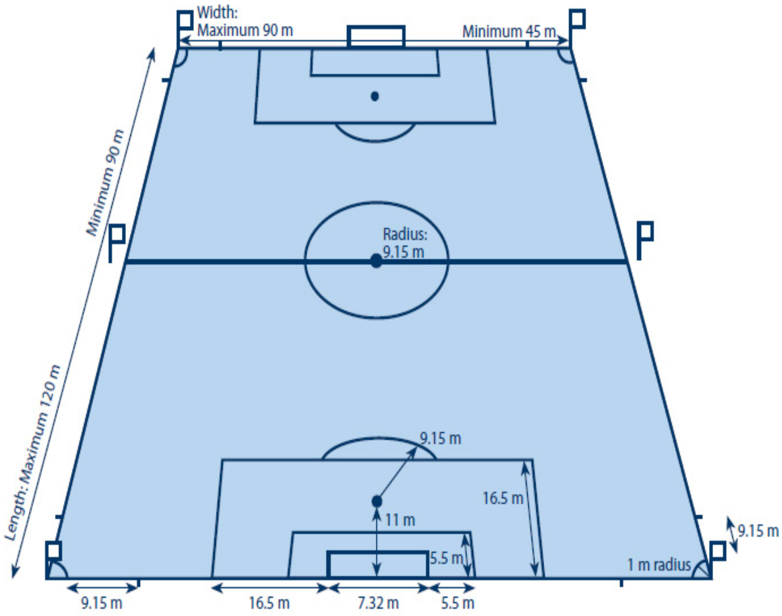

Fig. 4 Dimensions of a football field (Website of FIFA 2012)

Van Beijsterveldt, Krist, Schmikli, Stubbe, De Wit, Inklaar, Van de Port, & Backx (2001, 1), describe football as a "high intensity sport with continuous changes of direction and high-load unipodal actions." They go on to state that football subjects neuromuscular control, agility, and eccentric and plyometric strength to very high demands. In the following sections the individual requirements in football, the financial impact of injuries on the economic level, and the long term effect that injuries have will be considered.

4.1.1 Individual requirements in football

Football is a team game but it requires the combination of many different individual factors for one to be an effective and successful player. Fig. 5 shows the individual qualities involved in the game of football. If a player is lacking in one or more areas their overall football performance will be decreased.

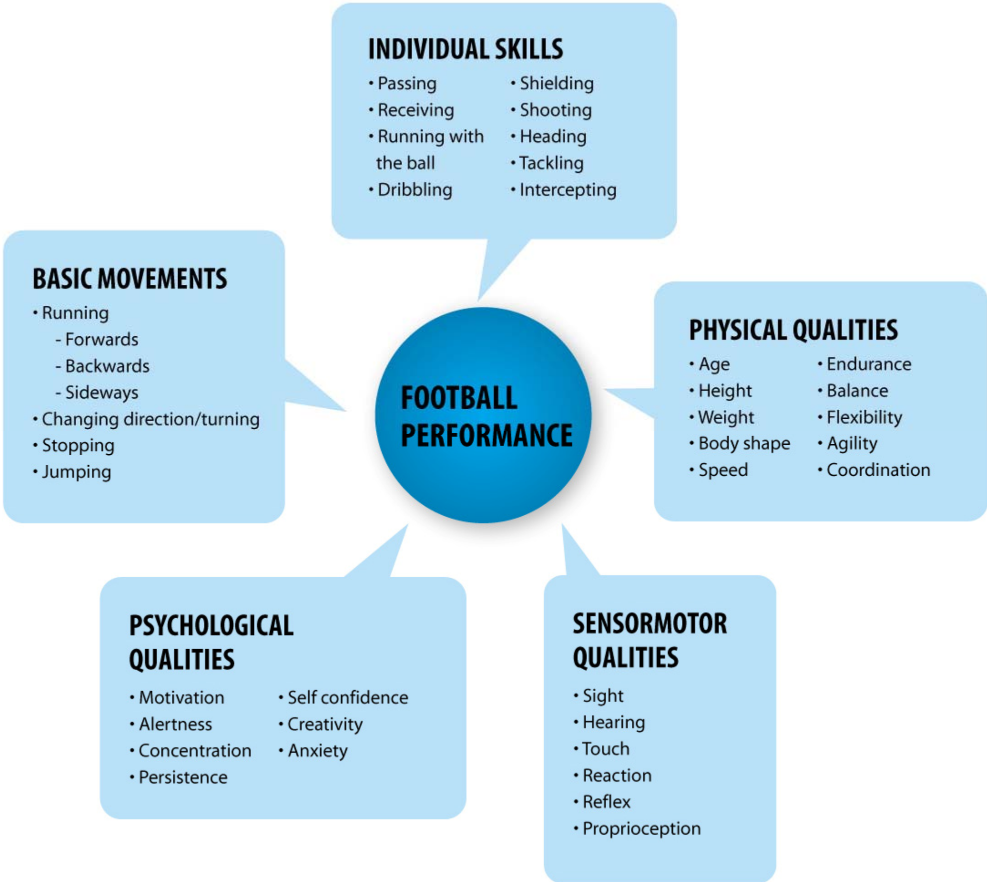

Fig. 5 Individual qualities in football (Adapted from the Website of CoachesInfo 2012)

The basic movements of football include accelerating, running forwards, backwards and side-ways, changing direction, decelerating, stopping, shooting, jumping, and heading. To perform these movements successfully the player must use a combination of their sensomotor skills, psychomotor skills and physical qualities and attempt to outperform their opponent.

While the majority of injuries in football are contributed to contact with another player, many are a result of no contact with another player (Hawkins & Fuller, 1999, 199). The basic movements involved in football place physical loads on the muscles and many strains and sprains are caused while performing these movements.

This thesis is observing the cause of anterior cruciate ligament tears in female players and many of these occur through non-contact mechanisms. The most common of the mechanisms to cause tears in the anterior cruciate ligament are when a player is changing direction and when a player lands after jumping (Silvers & Mandelbaum 2011, 19; Yu & Garrett 2007, 49). The exact reason for injuries occurring in these situations will be discussed fully later in the thesis.

4.1.2 Economic cost of injuries

When a player is injured all the attention is usually focused on questions, such as; when will the player be fit to play again? What is needed to help the player recover in the quickest possible time? What will the effect on the team be due to the injury of this player? How can we prevent this kind of injury in future? However, there is also an alternative viewpoint of the effect injuries have and that is their economic costs.

Minor injuries can involve some economical costs, but severe injuries can amplify the economical costs substantially. Silvers & Mandelbaum (2011, 18) stated that in the United States of America, the annual cost of an injury, such as an anterior cruciate ligament tear, can exceed 2 billion dollars. Van Beijsterveldt, et al (2001, 1) showed that even in the much smaller country of the Netherlands the estimated direct and indirect cost of sporting injuries are 1.3 billion euros annually. These figures also only looked at the cost of sporting injuries at the time of occurrence. The next section of this thesis will look at the long term effects of injuries where the effect on the economic cost is much harder to calculate.

By implementing proven injury prevention programmes, the economic cost of injuries should in turn be reduced. However, with the increasing amount of players participating each year the exact effect of an injury prevention programme on the economic cost will be inaccurate, as the economic cost will likely continue to rise as more amateurs with no access to sufficient prevention programmes will join the game.

4.1.3 Long term injury effects

The majority of injury cases are thought about with regards to their short term effect on the athlete. With modern techniques and treatments even the once career threatening anterior cruciate ligament injury can see a full recovery and return to game play within six months. However, the long term effect of injuries can have an effect on the athletes' quality of life for a much longer time then the career that preceded it.

Osteoarthritis is the most common of the long term effects suffered by ex-football players. Von Porat, Roos & Roos (2004, 269-273) found that there is a significantly higher incidence of knee osteoarthritis in male footballers 14 years after an anterior cruciate ligament injury. They also stated that this was irrespective of the treatment provided for the injury. Lohmander, Östenberg, Englund, & Roos (2004, 3145-3152) observed similar results in female footballers 12 years after anterior cruciate ligament injury. Furthermore, the onset of osteoarthritis was at a younger age on average in the affected players in comparison to their related age group.

In addition to these findings, Shepard, Banks, & Ryan (2003, 80-81) ascertained that ex-professional footballers where more prevalent to hip osteoarthritis than their equal age groups. The interesting point in this finding was that there was not always a history of injury within the affected hip. This suggests that due to repetitive nature of football, with the running, jumping, and turning, that the joints are subjected to an increased work load and therefore become susceptible to joint disorders.

These studies would suggest that even with the modern techniques and treatment programmes available, players that suffer an anterior cruciate ligament injury will be more susceptible to osteoarthritis in the future. In addition to this, they will also be at an increased risk of osteoarthritis the longer their career lasts. The effect of these injuries need to be addressed to improve the quality of the athletes future life and also to help reduce the economic costs that treatment for these joint disorders will cause.

5 THE ANTERIOR CRUCIATE LIGAMENT TEAR AND FEMALE FOOTBALL PLAYERS

According to Giza, Mithöfer, Farrell, Zarins & Gill (2005, 214) and Yu & Garrett (2007, 47-49), females are at a higher risk of knee injury and anterior cruciate ligament injury than males. This risk can be between two and eight to ten times more than male players (Silvers & Mandelbaum 2011, 18; Wojtys, Huston, Boynton, Spindler & Lindenfeld 2002, 182; Yu & Garrett 2007, 47). There are different theories why females are more susceptible to knee and anterior cruciate ligament injuries, the most common theories will be discussed in this section.

Firstly, Kobayashi, et al. (2010, 671-672) showed that close to 70% of anterior cruciate ligament injuries can be attributed to non-contact injuries, with the majority of these injuries occurring during competitive situations. They observed that 49.2% of anterior cruciate ligament injuries were caused during a match situation, 34.8% during a training environment, and only 8.5% were caused during leisure activities.

Wojtys, Huston, Lindenfeld, Hewett & Greenfield (1998, 614, 616) noticed a relation between the ovulatory phase and anterior cruciate ligament tears and therefore concluded that women may be more susceptible to anterior cruciate ligament injuries due to hormonal fluctuations. In later research, Wojtys, Huston, Boynton, Spindler & Lindenfeld (2002, 182, 184-186) studied the effect of hormonal levels during the menstrual cycle and the effect it had on anterior cruciate ligament injury rates. It was observed that there was a higher than expected incidence of anterior cruciate ligament injuries during the ovulatory phase of the menstrual cycle, but had a lower than expected incidence rate during the follicular or luteal phase. However, Vescovi (2011, 98) contests “that subtle menstrual disturbances were present in the sample of women from the Wojtys, et al study or that cycle phase was not appropriately identified.”

Another study that was performed by Anderson, Dome, Gautam, Awh, & Rennirt, (2001) considered the correlation of anthropometric measurements between males and females including, muscular strength, anterior cruciate ligament size and the anatomical characteristics of the intercondylar notch. The results suggested that the size of the anterior cruciate ligament was in direct correlation with the strength of the quadriceps muscles. As females had weaker quadriceps when compared directly with their male counterparts, including when adjustments where made to take into account the size difference of the individuals, it was suggested this could increase the risk factor of anterior cruciate ligament injuries in females. It should be noted that the study also showed a weakness in hamstring strength, while subjects who had strong quadriceps muscles usually had strong hamstring muscles. The stronger the muscles of the thigh the more support would be available for the knee and possibly reduce the risk of anterior cruciate ligament tears for both males and females.

They also observed no connection between the intercondylar notch and anterior cruciate ligament tears in both males and females. However, it was observed that should intercondylar notch stenosis occur it would increase the risk of anterior cruciate ligament tears for males and females. Another study by Shelbourne, Davis & Klootwyk (1998, 402, 405) considered the size of the intercondylar notch, they found that females have a narrower intercondylar notch compared to men; this was also observed when the men and women were the same size. It was shown in this particular study that when the intercondylar notch was the same size the rate of anterior cruciate ligament injuries was the same for men and women. However, this may suggest that due to females having a narrower intercondylar notch, they may be at a higher risk of injury to the anterior cruciate ligament.

Yu & Garrett (2007, 47-50) showed in their literature review that athletes with smaller degrees of knee flexion are more prone to anterior cruciate ligament tears. Furthermore, female athletes were found to have a smaller degree of knee flexion than their male equivalents. The smaller degree of knee flexion was observed mainly in running, jumping and cutting tasks, which are major causes for non-contact anterior cruciate ligament tears in females. Additionally, from the age of 13 onwards, females showed a reduced degree of knee flexion, these results have a direct correlation to the findings of Waldén, Hägglund, Werner, & Ekstrand (2011, 3-8), who stated that females are more prone to anterior cruciate ligament injury at a younger age than their male counterparts. The reason for the increased risk of injury due to a smaller degree of knee flexion may be due to the increase in patellar tendon tibia shaft angle. Yu & Garrett (2007, 48) found that on average females have a four degree greater patellar tendon tibia shaft angle then that of males. In addition, the patellar tendon tibia shaft angle is increased as the knee flexion angle decreased.

These studies have shown that there is a possibility that a single anatomical occurrence increases the risk of anterior cruciate ligament injury for female footballers. Although, Giza, Mithöfer, Farrell, Zarins & Gill (2005, 212) stated that there is no evidence that a single etiology is responsible for the increased risk of anterior cruciate ligament injury for females. In addition to the increased risk of anterior cruciate ligament injuries that have been observed, there is an increased risk of future complications, such as osteoarthritis, which have been discussed previously.

6 INJURY FACTORS

The previous section discussed the possibility of individual etiological reasons being the cause for increased risk of injury to the anterior cruciate ligament in females. Even though there may be a solitary reason that will be proven with future research, it is important to realize that there are many factors affecting an individual's risk of injury. Bahr & Krosshaug (2005, 327), use a model to show how multiple factors combine to increase the risk of injury in each player. Fig. 6 is an amended version of this model that uses the risk factors relevant to this thesis.

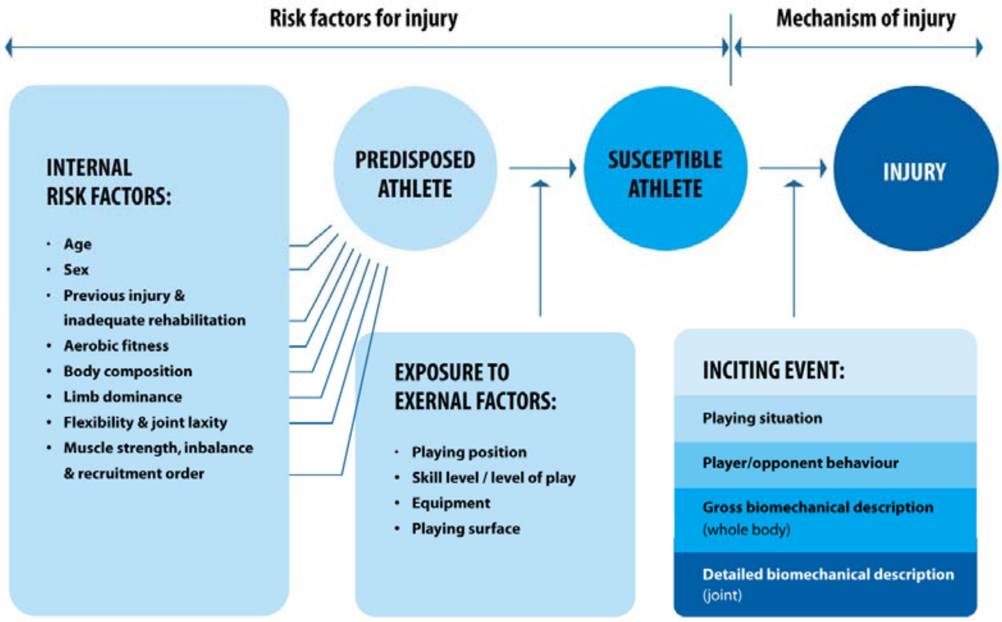

Fig. 6 Contributing factors to injury (Bahr & Krosshaug 2005, 327)

Therefore, as each individual player is unique, both coaches and players need to consider each factor independently of others. Doing this will allow the coach and player to have a better understanding and hopefully a reduction in injury rates

The individual risk factors are discussed in this section. Each risk factor will affect a player in a unique way. There are two areas in which factors are grouped, intrinsic and extrinsic, and according to Murphy, Connolly & Beynnon (2003, 13, 28) these risk factors have to be determined before considering an intervention program.

6.1 Intrinsic factors

Dvorak, Junge, Chomiak, Graf-Baumann, Peterson, Rösch, & Hodgson (2000, 69) describe intrinsic risk factors as the individual biological or psychosocial characteristics of a person. Intrinsic risk factors include age, sex, previous injury, inadequate rehabilitation, aerobic fitness, body size, limb dominance, flexibility, joint laxity, muscle strength, imbalance and reaction time. During this section each of these factors will be contemplated and discussed to the specific role they play in increasing the risk of injury.

6.1.1 Age

While there are several studies showing age as a factor in injury susceptibility, there are also contesting studies showing that age is not necessarily a contributing factor. Several studies (Chomiak, Junge, Peterson, & Dvorak 2000, 65; Dvorak & Junge 2000, 6; Hägglund, 2007, 14) have observed that the age of players could be an important influencing factor on the severity of knee injuries. They found that in the older age groups the more serious injuries, such as ACL ruptures and menisci tears were more frequent, while the lower age groups sustained injuries such as, partial ruptures of the collateral ligaments, sprains and contusions, which are seen as less serious injuries.

6.1.2 Sex

Whether the player is male or female may possibly have an affect on the rate of injury. According to Giza, Mithöfer, Farrell, Zarins & Gill (2005, 212) there are numerous studies that show females are at a higher risk of knee injuries, especially anterior cruciate ligament tears. Ristolainen, Heinonen, Waller, Kujala & Kettunen (2009, 447-448) studied a variety of sports including football and determined that there was no overall difference in injury rates between males and females. However, they did show that acute and chronic knee and ankle injuries where more common among female football players than their male counterparts.

There are different theories to why women are more susceptible to knee injuries than men. Wojtys, Huston, Boynton, Spindler & Lindenfield (2002) presented the idea that the menstrual cycle plays a crucial role in the level of injury rates seen in female football. They observed that more ACL injuries occurred during the ovulatory phase of the menstrual cycle. This suggests that the increase in estrogen during this phase has a direct impact on the proportion of ACL injuries. However, the study showed that more conclusive evidence is needed in this area.

Another theory proposes that the size of the intercondylar notch width has an impact on the frequency of ACL injuries in female football. Shelbourne, Davies & Klootwyk (1998) measured the width of the intercondylar notch on 714 patients, 480 men and 234 women, who had received autogenous patellar tendon graft anterior cruciate ligament reconstructions. Their results showed that while the intercondylar notch width did have an impact on the rate of ACL injury, the specific gender did not. Therefore, a female with the same size intercondylar notch width as her male counterpart would not pose any greater or less risk for ACL injury. It should be recognised though that the average size of the intercondylar notch width is smaller in females than in males, therefore increasing the prominence of injury to the ACL due to this factor.

6.1.3 Previous injury and inadequate rehabilitation

Previous injury and inadequate rehabilitation are the leading factors in the risk of future injury, with over a third of moderate to severe injuries occurring within two months of a player receiving a minor injury (Dvorak & Junge 2000, 7 & Dvorak, J. et al 2000, 73).

Female players have only a slight increased risk of reinjuring a previously sprained knee. However, there is a significantly increased risk of tearing to a previously injured anterior cruciate ligament (Faude, Junge, Kinderman & Dvorak 2006, 788). A previously torn anterior cruciate ligament also increases the risk of future injuries, which include, recurrent anterior cruciate ligament tears, and both traumatic and overuse injuries (Walden, Hägglund & Ekstrand 2006, 160). This highlights the importance of both an adequate prevention program and a suitable and structured rehabilitation period.

Fig. 7 Four step model for injury prevention research (Van Mechelen, Hlobil & Kemper 1992, 84)

In order to evaluate the effectiveness of an injury prevention program, the model in Fig. 7 (Van Mechelen, Hlobil & Kemper 1992, 84) should be applied. Bahr & Krosshaug (2005, 325) also stated that a precise description of each injury, and possible influencing factors, is essential in order for a successful injury prevention program to be devised.

6.1.4 Aerobic Fitness

Murphy, Connolly, & Beynnon (2003, 19) discussed the possibility that when an athlete becomes fatigued they will alter their muscle recruitment patterns. Due to the altered recruitment patterns, the athlete may then adjust the distribution of forces on joints, ligaments and muscular structures. However, they do conclude that there is not a clear relationship between aerobic fitness and injury, possibly due to the different techniques used to evaluate fitness.

Furthermore, Miura, Ishibashi, Tsuda, Okamura, Otsuka, & Toh (2004, 417) found that fatigue effects negatively towards knee proprioception. They go on to state that general muscular endurance training alone is insufficient and should be performed alongside a neuromuscular training program.

6.1.5 Body composition

Faude, Junge, Kindermann & Dvorak (2006, 786-787) observed that taller players were at more risk of injury than intermediate height players. They also ascertained that players with a heavier body weight were at a higher risk of non-contact injuries. Obviously, height is not a factor that can be affected. However, the weight of the player is a possible contributing factor to injuries and therefore a player and coach should strive to maintain a suitable weight throughout the players' career. It should be noted that the weight of an individual player should also be considered in relation to their body fat percentage. An athlete with a high body fat percentage may still be in the desired weight range, whereas if the player has a low body fat percentage but higher than suitable weight range their strength levels are likely to be higher and therefore possibly have less risk of injury.

6.1.6 Limb dominance

Faude, Junge, Kindermann & Dvorak (2006, 787, 789) displayed that the players' dominant limb is more susceptible to injury for both acute and chronic injuries. They suggested that due to more tackles being targeted towards the ball, and therefore the kicking leg which is usually the more dominant leg, more contact injuries occur. Obviously the continued use of one limb more than another will also increase the risk of chronic overuse injuries.

One possible solution for this would be that both players' and coaches would train from a young age both legs. This would result in the player being more versatile and potentially a better player, while also reducing the risk of injury to a dominant limb.

6.1.7 Flexibility and joint laxity

Witvrouw, Danneels, Asselman, D'Have & Cambier (2003, 41, 44-45) examined the risk of muscle injuries due to inflexibility in football players. They observed that inflexibility in the quadriceps and hamstring muscles were an indicator of potential injury. Also it is suggested that a preseason testing protocol is planned to measure the flexibility of muscles and predetermine players that are potentially at a higher risk of injury.

When performing a review of studies, Beynnon, Murphy, & Alosa (2002, 376, 379) found that joint laxity or instability did not play a factor in increasing injury risk. The study was focused on ankle sprains and the authors did state that more conclusive data would need to be taken to establish if joint laxity is a determining factor. However, in contrast to this study Rozzi, Lephart, Gear, & Fu (1999, 317) found that females had a greater degree of knee joint laxity, which they stated may effect negatively to knee joint proprioception and therefore increase the risk of impact injury to the knee.

6.1.8 Muscle strength, imbalance and recruitment order

Silvers and Mandelbaum (2011, 22) stated that muscular strength and recruitment order are essential in the ability to stabilize the knee. In addition, they stated that the relationship between the quadriceps and hamstrings is highly important. If the muscular balance is incorrect or muscle fatigue affects the recruitment of these muscle fibers in the correct order, the ligaments can be put under intensified pressure and will be at a higher risk of injury.

Anderson, Dome, Gautam, Awh, & Rennirt (2001, 64) also considered muscular imbalance and stated that the force produced by the quadriceps can increase anterior tibial translation and exceed the force required to rupture the anterior cruciate ligament. The hamstring muscle counteracts the force of the quadriceps contraction on the anterior tibial translation; therefore it is essential that there is appropriate muscle balance between the quadriceps and hamstrings.

6.2 Extrinsic factors

Extrinsic factors relate to environmental factors including playing position, skill level or level of play, equipment and playing surface. As with the intrinsic factors each of these areas will be discussed on their role, importance and effect on injury rates among football players.

6.2.1 Playing position

Faude, Junge, Kindermann & Dvorak (2006, 786-789) found that the players position has a direct affect on the rate of injury occurrence and the mechanism of injury. They found that defenders and strikers are at a higher risk of injury than goalkeepers and midfielders. They also observed that the majority of injuries suffered by defenders and strikers where caused by contact, whereas goalkeeper injuries where more likely to be non-contact mechanisms. These results can be seen in Table 1.

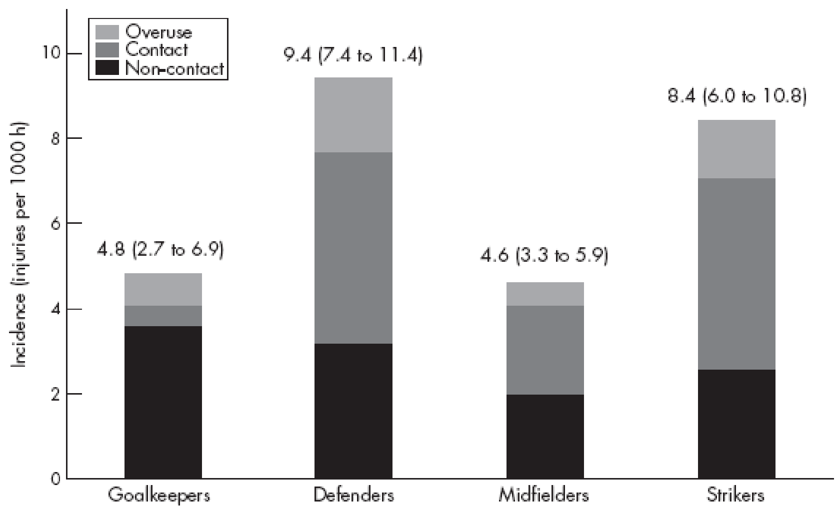

Table 1. Injury rates in relation to playing position (Faude, Junge, Kindermann & Dvorak 2006, 788)

A similar study was performed by Hawkins & Fuller (1998, 328-330); however they stated that there was no significant difference between injury incidence rates and stated that a player’s position is not a determining factor in injury rates. These results can be seen in Table 2

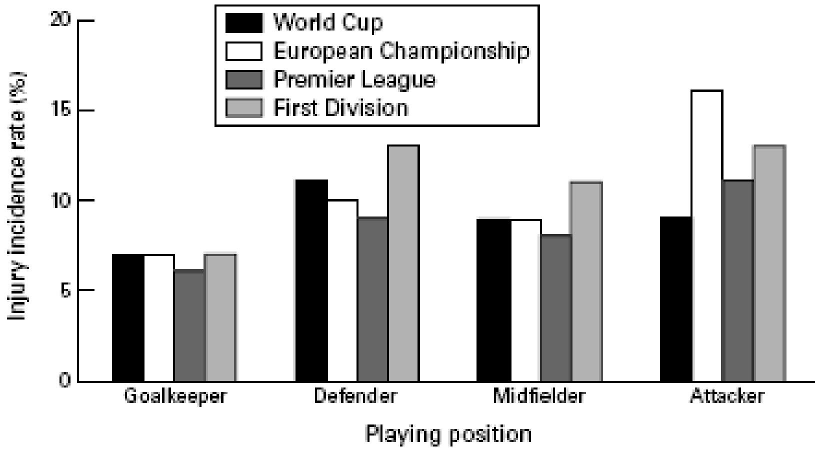

Table 2. Injury rates in relation to playing position (Hawkins & Fuller 1998, 329)

Hägglund (2007, 20) suggested that the difference in results between studies evaluating playing positions may be due to an inability to define a player’s position accurately. For example, at the beginning of the season a player may be listed as a defender but play the majority of the season in a holding midfield role. In addition to this Hawkings and Fuller (1998, 330) suggested that further studies should concentrate more on where on the field of play and at what stage of play the injury occurred. This could help account for if a defender is on an attacking run and actually playing ahead of the midfield, or a striker is in the box defending a corner. It would also allow for changes in formation that may cause a player of a certain position to play in a different role to first anticipated.

6.2.2 Skill level/level of play

There seems to be a lack of studies comparing the skill level or level of play with injury rates. However, Dvorak, et al (2000, 73) stated that lower level players tend to be at more risk to injury than that of higher level players. It is suggested that this may be due to the fact that less skilful players use more physical force to influence situations and therefore make themselves more prone to contact injuries than more skilful players. In addition to this Hägglund (2007, 17) observed that more injuries may occur during training of lower level players. This may be due to poor facilities and/or coaching, or it may be due to a reduced physical capacity as higher level players will generally train and play on a more regular basis.

6.2.3 Equipment

Correct and proper equipment and its importance should be taught to youth players to help reduce the risk of injuries throughout their involvement in football. Dvorak & Junge (2000, 7-8) found that studies show an increase in lower limb injuries when shin guards are inadequate or not worn at all. They also found that wearing an ankle brace on previously sprained ankles reduced the risk of further injury; this is echoed in Hägglunds (2007, 20) findings.

Woods, Hawkins, Hulse & Hodson (2002, 439) observed that the majority of football boots do not offer adequate support for the player. Players may also be inclined to buy the same boots they see the players wearing on television rather than the boot that best suits their foot type. Silvers & Mandelbaum (2011) also observed that even though an efficient friction surface, such as studs, need to be included in boot design, poor design could lead to excessive friction and an increase in ligament injuries. Alongside the boot design and type Waddington & Adams (2003, 173) studied the importance of the insole in the football boots in relation to risk of injury. They found that when using a rubber insole players had better responses to ankle inversion movements.

6.2.4 Playing Surface

Playing surfaces can vary with both grass and artificial turf being used in the Naisten Liiga. While the benefits of being able to play in conditions unsuitable for grass are clear, there has been questions about the effect on injury rates artificial turf may have.

Kordil, Hemmati, Heidarian, & Ziaee, (2011, 3-4) showed that the overall injury rate was close to two times higher on a grass field than on artificial turf. However, the injuries experienced on the grass field were defined as slight or minimal, whereas the injuries on artificial turf were defined as mild. In contrast to this Fuller, Dick, Corlette & Schmalz (2007, 32) found that there was no significant difference between injury rates on grass or artificial turf fields. The differences in these studies may be due to the artificial turf used; in order for a true comparison to be made the turf would have to be of the same material. Also in the study performed by Kordil, Hemmati, Heidarian, & Ziaee, (2011, 3-4) it is stated that the players selected where non professional players, however it was not stated at which level they do play. This has been shown as a possible attributing factor for injuries earlier in this thesis.

7 THE EXERCISE PACKAGE

The exercises selected in this package, that is to be used by the first team of Nice Futis Football Club, are the exercises that have been proven in previous prevention trial programs (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, Silvers, Watanabe, Knarr, Thomas, Griffin, Kirkendall & Garrett Jr 2005) to prevent injuries in footballers, especially anterior cruciate ligament injuries. In their respective studies the individual injury prevention packages have reduced injuries from 60% to 89%. (Silvers & Mandelbaum 2011, 23) There has been no research performed to date of what the exact amount of repetitions or the optimal time scale to perform these exercises, therefore within this exercise package the repetitions and/or time scales used for each exercise are the same as the studies in which they were performed.

7.1 Injury reporting

In order to obtain weather or not this exercise package is effective the injuries for the current season of 2012 were recorded. The injury reporting form used during the season can be seen in the appendix 1. The injury reporting form used was adapted from Lislevand (2010, 96). Throughout the season the injuries were recorded as they happened. However, some “injuries” that occurred, for example in a game or training situation, did not result in any restriction in playing or training time and where only listed in case there was a later injury that was related to the previous occasion. Injuries that had no effect on the player other than momentary pain were later removed from the results before attaching them to this thesis. Recording the injury types, how they occurred, and the rates of injury per game or training allows not only for future reference regarding this thesis but will also give an insight to the coaching staff as to what is the main causes of injury within the first team of Nice Futis Football Club. This will allow them to possibly adjust their training program, including the exercise package, and decrease the risk of injury further still. Chart 1 presents the percentile rate for the location of injuries during the season, while chart 2 represents the percentiles for the type of injuries that occurred.

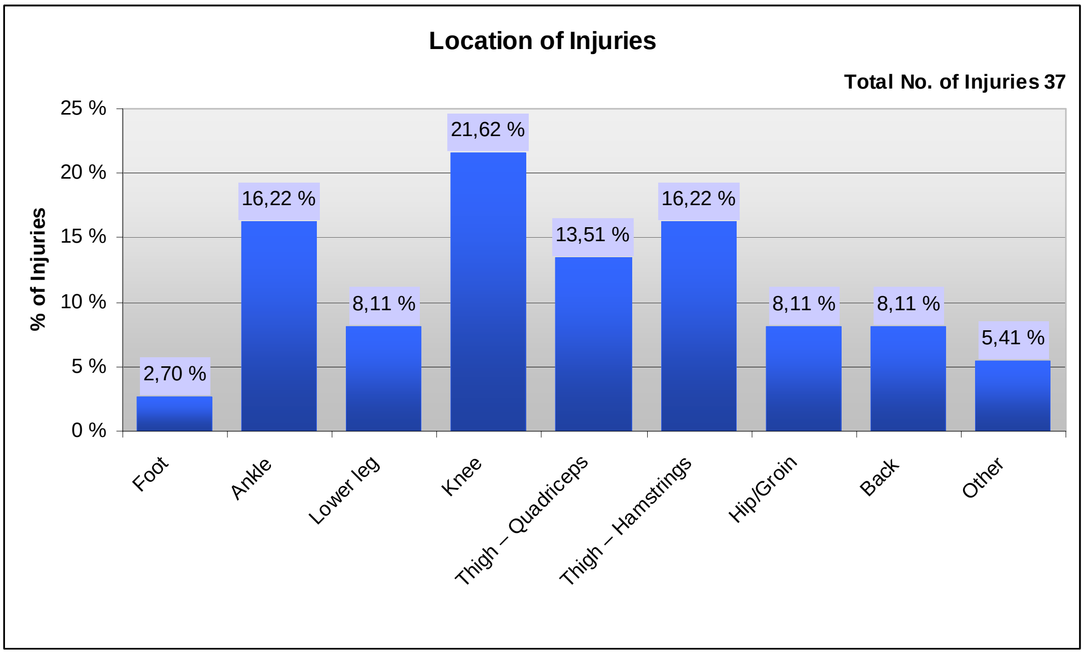

Chart 1. Location of injuries

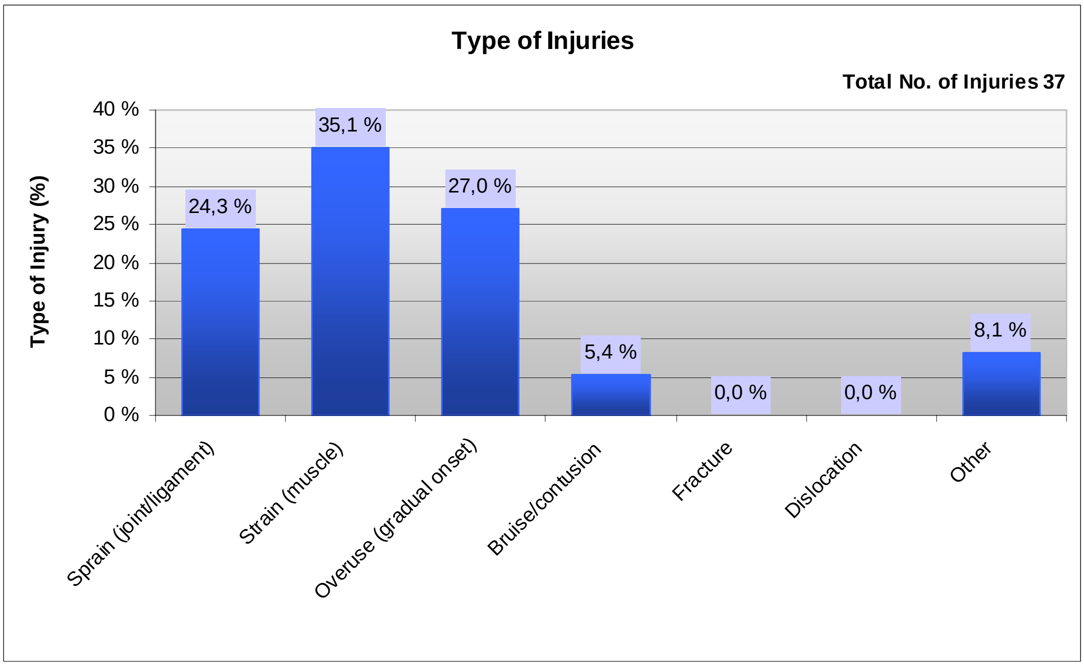

Chart 2. Type of injuries

7.2 Form of the package

The package has been formed using exercises proven to reduce the risk of anterior cruciate ligament injury in previous prevention trial programs (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005). In the majority of prevention programs the focus is only on one aspect of injury prevention, such as proprioception, with only a minority of prevention programs addressing multiple aspects in one combined package.

The structure of the package should also be easy to use and understand for both players and coaches to encourage a high compliance with the exercises and therefore decrease the injury risk to its upmost capacity. Each exercise will be able to be performed with minimal equipment, consequently allowing the program to be used by a larger proportion of teams and individuals.

7.3 Flexibility exercises

“Flexibility is the ability to move a joint through its complete range of motion. It is important in athletic performance and in the ability to carry out the activities of daily living.” (ACSM 2010, 98).

Static stretching exercises have long been associated with sports and increasing flexibility. Static stretching is when one or a group of muscles are slowly moved into a stretched position and held for a set amount of time. A static stretch will not activate the stretch reflex due to its relaxed starting position and gradual movement into the desired position. (Nelson & Kokkonen 2007, preface vi) The literature review performed by Weldon & Hill (2003, 144-145) showed that static stretching can have a positive effect on injury rates; although they stated that there is not a significant difference between static stretching and no-stretching during a warm-up. Furthermore, Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg (2010, 45) suggested that a static stretching program should not be included, especially in cases of joint laxity, unless specific limited joint range of motion is present. Due to females having a higher occurrence of joint laxity and the lack of evidence regarding the positive benefits of static stretching, no specific static stretching exercise will be included in this exercise package.

Therefore, the flexibility exercises include only dynamic stretching exercises. Dynamic stretching is when movements mimicking the required movements for the athletes sport are performed. These are fast moving exercises which cause the muscle to stretch. (Nelson & Kokkonen 2007, vi) Dynamic stretching should be used within a sports specific warm-up due to its positive effect on improving of short term performance. During a dynamic warm-up McMillian, Moore, Hatler & Taylor (2006, 496) found that athletes had improved results in agility and power drills, including T-drills, medicine ball throw for distance and five step jump test, when compared to a static stretching or no warm up. Little & Williams (2006, 205) had similar results in a ten meter acceleration test, 20 meter flying start maximum speed test and a zigzag agility test, although they showed no significant difference between dynamic stretching and static stretching when comparing the vertical jump test. Furthermore, Yamaguchi & Ishii (2005, 8-9) observed an increase in leg extension power when following dynamic stretching exercises when compared to both static and non stretching exercise. Kovacs (2010, 14) described the benefits of dynamic exercises as stretching, power, endurance, flexibility, coordination, balance, neuromuscular activation, speed and mental preparation. The combination of these can result in training adaptations that improve the athletic performance of an individual.

7.4 Muscular fitness exercises

“The ACSM has melded the terms muscular strength and muscular endurance into a category termed muscular fitness… Muscular strength refers to the ability of the muscle to exert force. Muscular endurance is the muscle’s ability to continue to perform for successive exertions or many repetitions.” (ACSM 2010, 86).

The exercises were selected on previous use in successful prevention trial programs (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005). During the season these exercises should be used throughout the training week at least 1-3 times, and follow a comprehensive warm-up, to maximize their effectiveness potential (Grindstaff, Hammill, Tuzson & Hertel 2006, 452-453). Muscular strength and balance has been discussed earlier in this thesis and its importance to injury prevention examined. In addition, muscular strength can improve the acceleration and movement velocities of the players (Hoff & Helgerud, 2004, 175). The exercises selected will promote muscular strength, endurance and balance. It should be noted that this exercise package is considering in-season training and players should undertake a specific resistance training program in their off and pre-season training schedules in order to improve muscle strength, muscle balance, power output and muscle recruitment order to the maximum potential, as due to the physiological demands on the muscles this type of training is not suitable during the season, except for those returning from injury.

7.5 Neuromuscular exercises

"Neuromuscular training includes balance, agility, and proprioceptive training." (ACSM 2010, 174) Plyometrics are also included in neuromuscular training (Mandelbaum, et al 2005) and will be included within this exercise package.

Numerous studies having proven that an adequate neuromuscular program incorporated into a sport specific training session can help to reduce the risk of potential injury occurrence. (Caraffa, Cerulli, Projetti, Aisa & Rizza 1996; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005) The selection criteria for these exercises were that they had been used in a previous successful injury prevention trial programs (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson

& Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005). As mentioned previously some exercises have multiple benefits, such as, strength and balance combined, however they will be only listed within one area and not multiple areas.

As with the dynamic flexibility exercises emphasis should be on correct technique by each of the players, this allows for the correct motor learning to be achieved. The exercises used in this section are again the exercises that have been used in previous studies and have been shown to reduce injury rates to the athletes performing them. In order for the exercises to be most effective they should be performed at the beginning of the training session, at least 1-3 times per week, following a suitable warm-up and dynamic flexibility training program (Grindstaff, Hammill, Tuzson & Hertel 2006, 452-453).

7.6 Exercise prescription

The exercises selected for the exercise package focus on the specific muscles and movement patterns required for football. Each exercise should be performed with the correct movement patterns, with the most emphasis on knee position. The movements should not be performed when the knee is in a valgus position, training the knee in the correct position will allow for motor learning of the correct technique and therefore should allow the player to perform the movement later in a game in the correct way and remove a significant injury mechanism from the movement. The exercises in the package are a combination of previous injury prevention trial program exercises (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005). These exercises have been proven to be successful in helping to reduce injury rates in footballers during implementation of these programs.

The flexibility exercises are to be incorporated into the general warm-up performed before every training session and match. Mann & Jones (1999, 55) stated that the dynamic exercises should not cause undue fatigue. Furthermore, Bishop (2003, 484-485) observed that, in order to be effective, exercises performed before an activity should not deplete the high energy phosphates available to the athlete. Therefore the selected repetition and set range has been selected using the previous injury prevention trial programs (Hewett, Lindenfield, Riccobene & Noyes 1999; Junge, Rösch, Peterson, Graf-Baumann & Dvorak 2002; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson & Byberg 2010; Kirkendall, Junge & Dvorak 2010; Mandelbaum, et al 2005), due to their proven success.

The muscle fitness and neuromuscular exercises are to be performed during training sessions only and not on match days. Two or three exercises, dependant on the training session load, should be selected from each category for each session. The players are to work in pairs for the movements and should be partially responsible, alongside the coaches, for correcting their partners movement patterns.

8 THE PROCESS OF THE THESIS

The initial idea for the thesis was contemplated in the spring of 2011; however the thesis was not worked on consistently over this entire time period. The main reason for choosing this topic was for a number of reasons; firstly, I have played football all of my life and have a great interest in the sport and would like to work as a physiotherapist at a top football club within my career. Secondly, I have also had many injuries during my years of playing football, mainly affecting the knees. Thirdly, when I began the thesis process, the research literature showed that anterior cruciate ligament injuries in women’s football are highly prevalent while lacking in any real structured exercise programs.

The original concept in the spring of 2011 was an exercise package for prevention of all knee injuries in football which turned out to be too wide a topic for the scope of this thesis. I began researching and writing with this aim in mind, however, due to inexperience I did not save my thesis to multiple places and therefore lost a large portion of work. Nevertheless, this proved to be a good thing as it allowed me to narrow my vision to focus solely on the anterior cruciate ligament and women's football. I then began writing in earnest in the summer of 2011. It was very difficult to begin as there was a multitude of information available and therefore difficult to know where and how to start. I did not make a precise schedule during this time and by the end of the summer had not progressed as much as I felt I should have.

In April 2012 I made first contact with Nice Futis Football Club and agreed to create the thesis in collaboration with them. It was then in summer 2012 that the work really started. In the beginning I managed to produce text effortlessly, however after a while I struggled with the writing process, I left the thesis aside at this point for a month and a half and concentrated on other areas of my studies. When I returned to it, I had learnt from my previous mistake and made a precise schedule. The process of the thesis then became easier. I am happy with my thesis and feel that it really has a practicable use in the world of women's football. Fig. 8 depicts the journey my thesis has taken over the last 1.5 - 2 years.

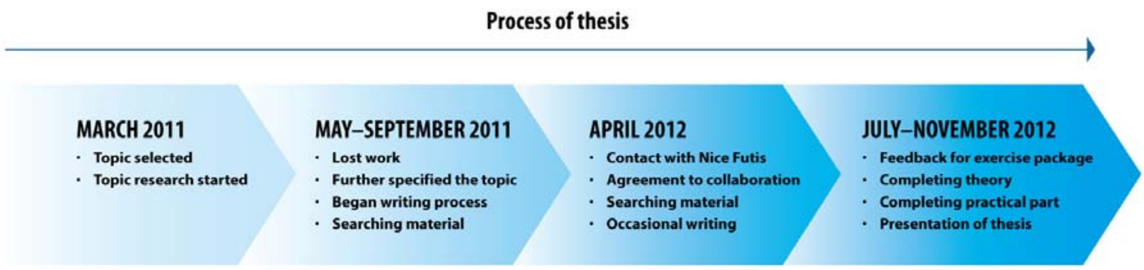

Fig.8 Process of the thesis

9 DISCUSSION

The purpose of this thesis was to provide players and coaches a unified selection of proven injury prevention exercises for the anterior cruciate ligament. The literature used for this thesis has shown that a successful injury prevention program can help to reduce the rate of injuries, reduce the economical cost caused by injuries, reduce future health problems for the players, and can educate both players and coaches to be more aware of individual player needs.

Injury prevention programs have been proven to be successful in numerous studies with reduction of injury rates ranging from 60% to 89%. (Silvers & Mandelbaum 2011, 23) However, the majority of injury prevention research has been performed using individual factors such as proprioceptive exercises or stretching programs. This thesis combined the exercises that have been clinically tested into one package so that the players and coaches could use one simple booklet when planning a training session. There have not been any studies performed that examine the exact amount of repetitions or time scale that should be used for these exercises. Therefore, the exercises have been used with the same repetitions or time scales as used in the studies.

During the thesis the injury rates of the first team of Nice Futis Football Club were recorded by the author in order to see in what areas and circumstances injuries occurred. This will allow for future evaluation of the injury prevention exercise package. New evidence is always emerging in the field of injury prevention and new exercises may be added or old ones removed as more specific evidence is made available through evidence based research. At this time all of the exercises used have been proven to work when used together, however, it is not possible to say at this point if one individual exercise is more efficient than another and only future studies would be able to prove or disprove certain exercises.

One issue with evaluating the effectiveness of injury prevention programs in general is that if mistakes are made in the recording of injuries this could have an impact on the perceived effectiveness of the program. Bjørneboe, Flørenes, Bahr & Andersen, (2010, 4-5) showed that medical staff often underestimated the amount of playing and training time lost due to injuries and player recall of injuries was poor. This suggests that injury reporting should be performed at the time of injury and not at a later date. During this thesis the injury reporting was not started until near the end of the season and players were asked to recall previous injuries. This was not the optimal way to record the data and will almost certainly have an effect on any future evaluation of the exercise package.

There would be a further possibility to implement this exercise package more comprehensively by including a coach and player educational course or additional material to enhance the learning experience. The thesis met its intended purpose of supplying an exercise package to the first team of Nice Futis Football Club, however, while working alongside the club and players it has become clear that further education would be needed, other than a booklet, in order for the prevention exercises to be used in the best possible way and have a greater effect on reducing injury rates.

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APPENDIX 1

Injury Report Form

Injury no.	1	2	3	4	5	6	7	8	9	10
1. Age of player										
2. Body Part										
Foot										
Ankle										
Lower leg										
Knee										
Thigh – Quadriceps										
Thigh – Hamstrings										
Hip/Groin										
Back										
Other										
3. Injury Type										
Sprain (joint/ligament)										
Strain (muscle)										
Overuse (gradual onset)										
Bruise/contusion										
Fracture										
Dislocation										
Other										
4. Injury Description										
New injury										
Re-injury										
Exacerbation (worsening of existing injury)										
5. Absence from football										
Continued playing and training										
Continued playing but then could not train										
Out for 1-3 days										
Out for 4-7 days										
Out for 8-28 days										
Out for 28 days+										
6. Injury mechanism										
Contact with another player										
No contact with player										
Contact with the ground										
Other										
7. Place of injury										
Training										
Match										
8. Date of Injury (Roughly)										