"Is foot type an indicator of the type of injuries that might occur in sporting people?"

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1. Abstract

Certain foot types have been suggested to be a predisposing factor in sporting injuries. This study investigated whether there was a correlation between foot type and anterior cruciate ligament injuries in footballers that play at all levels, from amateur to professional. Twenty-five footballers that had sustained an anterior cruciate ligament (ACL) injury and a control group of twenty-five footballers, which had no history of ACL injury, took part. All participants filled in a questionnaire and foot type assessment was measured using Staheli arch index from a footprint, defining whether a participant's foot type was pronated, supinated or in a neutral position. A chi-square test was used to analyse the data and the results of this study show that footballers with a supinated foot type are more prone to ACL injury (P-Value = 0.001).

2. Introduction

2.1 Title

"Is foot type an indicator of the type of injuries that might occur in sporting people?"

(A study focusing on whether there is a correlation between foot type and anterior cruciate ligament injuries in male footballers, ranging from amateur level to professional level.)

2.2 Why this topic?

Due to better health education demonstrating the benefits of exercise, sporting activities are more common amongst both males and females. As a consequence of this increased activity, sporting injuries are on the increase, particularly to the lower limb, and rupture of the anterior cruciate ligament has been the most common (Cross, M.1998). It has been estimated that the cost of sports injuries worldwide is costing $1 billion annually (Murphy *et al,* 2002). Due to this very high figure, prevention of certain injuries needs to be addressed and many researchers are now focusing their studies on the prevention of, and intervention in, sporting injuries (Murphy *et al*, 2002).

This study will be focusing on whether there is any correlation between a certain foot type and anterior cruciate ligament injuries amongst football players. It is believed that certain foot types may be responsible for other types of injuries, especially amongst runners. According to (Mckenzie *et al,* 1985) a runner with excessively pronated feet is more likely to be predisposed to injuries such as tibial stress syndrome, patellofemoral pain syndrome and posterior tibialis tendinitis and a runner with a pes cavus foot type may suffer from iliotibial band friction syndrome, peroneus tendonitis, stress fractures, trochanteric bursitis and plantar fasciitis. It is apparent that little research has been carried out surrounding the possible connection between foot type and injury and therefore this piece of research will focus on this particular area.

Football is the world's most popular organised sport with over 200 million males and 21 million females registered with the Federation Internationale de Football Association (FIFA). Studies have shown that 10-35 injuries per 1000 game hours were occurring amongst male footballers. The most common types of injury were muscle strains (30.7%), sprains (19.1%) and contusions (16.2%) and fractures (11.6%) and the most common sites of injury were the knee (31.8%) and head (10.9%) (Giza *et al,* 2004). Several Studies have identified that there is a higher incidence of knee injury and anterior cruciate ligament injury in female football players than male (Giza *et al*, 2004). The reason for this is unknown but many researchers have tried to apply their own theories as to why, none of these having yet been proved. In a study carried out by Giza *et al*, 2004, results showed that sprains were often grouped with anterior cruciate ligament injuries; the reason for this was not noted or found.

The aims of this study primarily are to discover new findings that could lead to the prevention of cruciate ligament injuries in football. This in turn would help in the field of podiatry as insoles could be used to help correct the biomechanics of the foot. No previous research has conclusively identified the correlation between foot type and sports injury.

2.3 Aims

The aims of this research

- To use a standardised questionnaire and a Baileys Pressure stat to take a foot imprint and to identify whether there is a connection between foot types (pronated or supinated) and anterior cruciate ligament injuries (a specific injury to the knee), using chi-squared.

- To evaluate the results and from the information gathered, which should lead to statistically significant results and therefore may lead to improvements in the prevention of knee injuries in football.

- To highlight any limitations within this study, so that future studies will be more efficient, valid, and the results be of greater significance.

Hypothesis 1:

There will be a significant correlation found between supinated foot types and ACL injury.

Null Hypothesis 1:

There will be no correlation found between supinated foot types and ACL injury.

Hypothesis 2

There will be a significant correlation found between pronated foot types and non-ACL injury.

Null Hypothesis 2

There will be no correlation found between pronated foot types and non-ACL injury

Hypothesis 3

There will be a significant correlation found between a neutral foot type and ACL injury.

Null hypothesis 3

There will be no correlation found between a neutral foot type and ACL injury.

Level of significance

If the P-Value < 0.05, then the results will be seen as statistically significant.

2.4 Glossary of terms

Excessive Pronation: (Pes planus)

Pronation is the term used to describe the movements of abduction, dorsiflexion and eversion of the foot. Pronation is when the medial aspect of the foot rolls inwards at the subtalar joint, causing the medial longitudinal arch area to appear flattened. During the gait cycle it is classified as normal if there is a degree of pronation at the subtalar joint during the contact phase. However, if the pronation phase continues past the contact phase it demonstrates that there may be a biomechanical problem (Agosta, J. 1993). An excessively pronated foot may also present with the following clinical signs: calcaneal eversion, talonavicular subluxation, abduction of the forefoot, 'too many toes' sign and a 'C'-shaped lateral border. The Helbings sign can also be a sign of excessive pronation. (Beeson, P & Nesbitt, P, 1995)

Excessive Supination: (Pes cavus)

Supination is the term used to describe the movements of adduction, plantarflexion and inversion. Supination is the opposite of pronation. It describes when the foot appears to be leaning over onto the lateral border of the foot and a high arch is generally apparent.

'Supination may occur to compensate for structural foot abnormalities, muscle weakness or muscle spasms. This foot type is a very poor shock absorber and so therefore may be predisposed to more injury.' (Agosta, J. 1993)

<u>Table of common injuries associated with biomechanical abnormalities</u>

Injury	Common biomechanical abnormalities
Sesamoiditis	Pronated foot Abducted gait Limited first ray range of motion Forefoot valgus/planterflexed first ray
Plantar Fasciitis	Pronated foot / High arched foot Abducted gait Ankle equines
Achilles tendinopathy	Pronated foot Ankle equines
Peroneal tendinopathy	Pronated foot at toe-off Excessive supination
Medial shin pain	Pronated foot Ankle equnius Varus alignment Abducted gait
Patellar tendinopathy	Pronated foot Tight quads, hamstrings and calves Anterior pelvic tilt Varus alignment
Metatarsal stress fractures	Pronated foot Supinated foot
Navicular stress fractures	Pronated foot Varus alignment Ankle equines
Fibular stress fractures	Supinated foot Pronated foot Varus alignment
Patellofemoral pain	Pronated foot Anterior pelvic tilt Varus alignment Abducted gait

(Agosta, J. 1993)

<u>The Knee</u>

"The knee joint, the tibiofemoral joint, is the largest and most complicated joint in the body. It basically consists of two condylar joints between the medial and lateral condyles of the femur and the corresponding condyles of the tibia, and a gliding joint between the patella and the patella surface of the femur." (Snell, R, 2004). Within the joint are many ligaments, which can be divided into two groups; extracapsular ligaments and intracapsular ligaments. There are two main intracapsular ligaments and these are known as the cruciate ligaments: anterior cruciate ligament and posterior cruciate ligament. (Snell, R. 2004)

The Cruciate Ligaments

"The cruciate ligaments are two strong intracapsular ligaments that cross each other within the joint cavity. These important ligaments are the main bond between the femur and tibia throughout the joint's range of motion" (Snell, R. 2004). The ligaments are named in relation to their attachment to the tibia. (Agosta, J.1993)

Anterior Cruciate Ligament (ACL):

"The role of the anterior cruciate ligament is to prevent forward movement of the tibia in relation to the femur and to control rotational movement. The ACL is essential for control in pivoting movements. Without an intact ACL, the tibia may rotate under the femur in an anterior-lateral direction" (Agosta, J. 1993).

"The anterior cruciate ligament not only stabilises the tibia against abnormal internal rotation, it also serves as a secondary restraint against valgus and varus stress." (Heitz et al, 1999)

3. Literature Review

Due to a substantial increase in sporting activities amongst both males and females, there has been a remarkable rise in sporting injuries, particularly to the lower limb, and rupture of the anterior cruciate ligament has been the most common (Cross, M, 1998). For many years researchers have been looking into the main causes behind why sporting injuries occur. Many theories have been put forward and many studies have been found to be conclusive; however, due to different methods being used, different variables may have influenced the results and accordingly have shown little agreement with previous study results. The causes of most sporting injuries are considered to be multifactorial and because of this, research continues. There are many factors that need to be taken into consideration when trying to assess what the actual cause of an injury is. Murphy *et al,* 2002, suggests that further studies are needed, using sufficient sample sizes of males and females, including collection of exposure data, and using established methods for identifying and classifying injury severity in order to conclusively determine additional risk factors for lower extremity injury. There are many possible intrinsic and extrinsic factors that could cause the injuries and these will be discussed.

3.1 Sporting Injuries

Over the years, research into the prevention of sporting injuries has been of great interest to many athletes, medical staff and many people involved within the sporting field. Not only do injuries cause a decrease in physical activity, but they can also result in long periods of time away from work and sport. In addition to this, it has been estimated that the cost of sporting injuries worldwide is $1 billion annually (Murphy *et al*, 2002). When carrying out the studies, it is important to look at the different extrinsic and intrinsic risk factors that could contribute to the susceptibility of an athlete to injury and it is important to describe the inciting event or mechanism of injury (Krosshaug *et al*, 2005). A complete description of the mechanisms for a particular injury type in a given sport needs to account for the events leading to the injury situation and it is also important to include a description of whole body and joint biomechanics at the time of injury. For a model of prevention within sport to be devised, considerations must be given to how internal and external risk factors may modify injury risk (Bahr and Krosshaug, 2005).

Brooks *et al*, 2005, looked at the epidermiology of injuries in English professional rugby union. Their study reported full details on the location, diagnosis, severity and mechanism of each injury of all 546 rugby players, all of whom had incurred an injury during the two season prospective study. The most common injuries were located in the lower extremities; this was also reported in a study comparing injuries in women's professional soccer (Giza et *al,* 2005). The two most common pathologies found were muscle/tendon and joint/ligament alignment injuries. Although within this sport, thigh haematomas were the most common and hamstrings injuries were the second most common. It was noted however that anterior cruciate ligament, medial collateral ligament, and knee meniscal/articular cartilage injuries were particularly severe and also resulted in the highest total number of days absent from the sport. The majority of injuries were also caused by contact mechanisms, which was also found by Emery *et al*, 2005 in adolescent soccer and Ramirez *et al*, 2006 in American football, whereas within English professional football, Hawkins, 1999 reported, there were more injuries caused by non-contact mechanisms. The most common injury sites found within the epidemiological study in English professional football were also found to be in the lower extremity (86%) and were classified as muscular strains or contusions, with the thigh (23%), ankle (17%) and knee (14%) being the most common (Hawkins, 1999). These statistics were also confirmed during a study carried out by Hawkins *et al*, 2001. Ramirex *et al,* 2006, also confirmed that lower extremity injuries were the most common, as did Emery *et al*, 2005, within adolescent soccer players, with the knee and ankle being the most common in both girls and boys.

Deitch et al, 2006, looked into the injury risk amongst professional basketball players, using 1145 individual players from the National Basketball Association (NBA) and Women's National Basketball Association. Over a 6-year study period, 4,446 injuries were reported. Of these injuries 2,888 (65%) were within the lower extremity and the knee was the most frequently injured structure, totalling 904 (20% of injuries). A total of 36 ACL (anterior cruciate ligament) injuries were also reported, accounting for 0.08% of all injuries. Across many sports, including American football, soccer and basketball, the National Collegiate athletic injury surveillance system for 2004-2005 found that the most common injury sites in all these sports were the ankle, knee, thigh and lower leg.

3.2 Anterior Cruciate Ligament Injuries

Anterior cruciate ligament injuries are on the rise, due to the increase in health promotion, which in turn has led to an increase in sport participation. ACL injuries are common in both males and females and the ACL is thought to be the most frequently ruptured ligament of the knee (Johnson, R, 1982) especially amongst athletes who participate in sports involving running, cutting, and jumping manoeuvres (Bonci, C, 1999), such as football, volleyball, basketball and rugby. Patients who have suffered an ACL injury have often described the injury occurring when landing, stopping, or when planting to change direction (Kirkendall, D and Garrett, W, 2000). According to Griffin *et al*, 2000, approximately 50,000 ACL reconstructions are done each year, at an approximate cost of $17,000 per procedure. This figure does not include the initial care of all ACL injuries or the conservative management and rehabilitation of patients who do not undergo ACL reconstruction. Webb, J. 1998, reviewed whether reconstruction of a ruptured ACL was a necessity in players who had suffered the injury, however they found that the loss of use of the ACL seemed to affect both the biomechanical and neuromuscular, or proprioceptive mechanisms that maintain the functional stability of the knee and stated that the effect of this impairment on atheletes can vary greatly. Preventative measures are currently being researched, however before a successful preventive model can be put in place, all intrinsic and extrinsic factors that may contribute to an athlete's susceptibility to injury, must be investigated (Bonci, C, 1999).

3.2(a) Hyperpronation and an ACL injured Knee

In recent studies it has become apparent that there could be a strong link between hyperpronation and ACL injuries, due to abnormalities in the biomechanics, leading to increased demands on other structures in the lower extremities, such as the knee. "An excessively pronated foot may cause excessive internal rotation of the entire lower limb during weight-bearing and this increases the demand on many structures." (Agosta, J.1993). According to Bonci, 1999, "The demand is increased as pronation is classified as the decelerating phase of movement, if pronation continues past the contact phase, the tibia will be forced into an increased internally rotated position, resulting in abnormal forces transmitting upward through the kinetic chain. Due to the internal rotation, the ACL is then forced into a tightened position, leading to increased demand, which may produce a preloading effect on the ACL", which could be a precursor or cause of ACL injury.

Moul, J, 1998, carried out a study to investigate whether there was a difference in strength, Q-angle, and pronation between healthy collegiate male and female basketball players. Twenty-three males and twenty-five females were used in the study, all of whom were playing NCAA Div.1 basketball. Three tests were carried out on each participant: a strength test to assess quadriceps and hamstring strength, a measurement of Q-angle, and an evaluation of pronation, using the navicular drop test. Their results indicated that there was a significant difference in eccentric hamstring strength relative to concentric quadriceps strength between the genders and in addition the Q-angle measured at 30 degrees of flexion also appeared to have a significant difference. Many other researchers have looked into the function of the hamstrings and the quadriceps and have found that the hamstrings help to reduce the tension of the ACL as they decrease internal tibial rotation (More *et al*, 1993). These findings were also confirmed by, Baratta *et al*, 1988. Baratta *et al,* 1988, also stated that an individual with hypertrophied quadriceps without complementary hamstrings strength is predisposed to an ACL injury. From the results found by Moul, 1998, it is apparent that there is greater strength in the male muscle groups than females, which could suggest a reason why females are more prone ACL injury. The significant difference in the Q-angle, with the females being larger, is also important as an increased Q-angle is linked to increased tibial rotation (Moul, J, 1998), leading to excessive genu valgum, which as stated earlier will increase the tension of the ACL, which could predispose the athlete to ACL injury (Bonci, C, 1999). Williams *et al*, 2001, also found that athletes with an excessively pronated foot were also more prone to external knee rotation during the first part of stance, which would also lead to an increased Q-angle, which could then cause malalignment of the patellofemoral joint, which through contact forces may be responsible for increased strain of the knee structure. Within the study carried out by Moul, J, 1998, little was discussed regarding the pronation aspect of the study. This suggests that little correlation was found. However, further studies carried out by Loudon *et al,* 1996 and Trimble *et al,* 2002 have suggested that there is an association between excessive pronation at the subtalar joint and ACL injury.

Beckett *et al,* 1992 also investigated the incidence of hyperpronation in the ACL injured knee. Their study focused on fifty participants who had previously suffered an ACL injury and fifty participants who had no medical history of lower extremity injuries. Within this study they measured the pronation of the participants using the navicular drop test, the same test used in Moul's study. Their results showed that the participants who had suffered a cruciate ligament injury had greater navicular drop tests score than those who had no history of injury. This suggests that there is a strong possibility that there is a connection between ACL injury and hyperpronation of the foot. However even though this study has used a sufficient sample number, only one test was used. For a more reliable set of results, a number of tests could have been carried out and then this information could have been compared and analysed. The sample group was also a mix of gender, which could be seen as a variable. Even though the results have shown that pronation could be a causative factor in ACL injuries, further investigation is still needed. Other studies concentrating on different injuries within different sports have also been carried out to see whether foot type, particularly the pronated foot type, is connected to other types of injury; these studies will be discussed later in the dissertation, however the results generally suggest that there is a strong correlation between the two factors.

3.2(b) Intercondylar Notch

In 1938, Palmer suggested that there might be a correlation between narrow intercondylar notch and ACL injury (Lombardo *et al*, 2005). Since then many investigations have been carried out to see if this suggestion was significant. Once again, many of the findings are contradictory of each other and the validity of the methods used to measure the intercondylar notch are also often under scrutiny (Angelo *et al,* 2004).

Lombardo *et al*, 2005, focused a study on whether intercondylar notch stenosis was a risk factor for ACL injury in professional male footballers. Using radiographs, 615 basketball players had the femoral notch and the distal condylar widths were measured between 1992 and 1999. All information regarding the players medical and injury history was gathered using the National Basketball Trainers' Association (NBTA) database. The results were not found to be significant in this study as there was no association between the Notch Width Index (NWI) in ACL-injured players and non ACL-injured players. Even so, this study did have its limitations as it only focused on elite male basketball players, which did not really represent the rest of the sporting population. Radiographs were also only taken of one knee. This study could also be considered to be gender biased.

However, other studies in other areas have also been carried out, using the same methods of measurement, radiographs, to measure the NWI and their results have also been insignificant. Angelo *et al*, 2004, analysed 23 pairs of radiographs of male individuals with no record of ACL injury and 16 pairs of radiographs of male individuals with unilateral ACL injuries. However, when a comparative analysis was carried out between the two groups, once again no significant statistical differences were found. Herzog *et al*, 1994, also supported this in his study when he also found that there was no significant difference in NWI in athletes with chronic ACL tears and athletes with no history of ACL tear.

Literature that supports the theory that there is a correlation has been written by Houseworth *et al*, 1987. They focused their study on 50 patients with an acute ACL tear and used a control group of 50 patients who had no history of knee injury. Using a notch view roentgenogram, the intercondylar notch widths were taken and then compared using a computer graphics programme. The results showed that a knee with a narrowed posterior arch was more likely to be prone to ACL injury. Although this study shows a correlation, the results are slightly dated and the technique used for measurement may not be as modern as that used in more recent studies. This study did however use a control group and of a substantial size. More research is definitely needed in this area.

It is strongly believed amongst many of the researchers that there is still a strong possibility that there is a link between the two factors. Palmer, 1938 stated, “The discrepancy between the data is probably due to our constitutional morphologic characteristics sample, since our anthropometrics standards considerably vary between different populations.” (Cited in Angelo *et al,* 2004).

3.2(c) Race

Difference in the rate of ACL injuries in different ethnic and racial groups is an area where very little research has been carried out. However in 2006, Trojian *et al,* carried out a study in women's basketball to see if there was any evidence that there is a difference in injury rate between white European American (WEA) players and non-white European American (non-WEA) players. Using the Women's National Basketball Association (WNBA) injury surveillance data, they found that there was a large difference in the rate of ACL tears between WEA and non-WEA players. The rate of ACL tears per 1000 athletic exposures was 0.45 for WEA players, however in non-WEA the results were 0.07. Unfortunately there were only 9 injuries reported within the time span used by the researchers, which is an extremely small number. As this was also a retrospective study there were many limitations involved and the information used was that only submitted by other people. This information could have been filtered and there is also the possibility that false statements could have been used. Further studies are needed in this area, also including other ethnic and racial groups.

3.2(d) Familial predisposition

Once again this is an area where very little research has been carried out, yet the results found by Flynn *et al, 2005,* appear to be statistically significant. A questionnaire based study design was used, asking questions regarding the history of knee injuries, demographics and sporting injuries. Information regarding all their family members was also recorded. The information gained was then divided into sub categories, contact sports and non-contact sports, and the information regarding the family members was also analysed. Their results showed that a person with an ACL tear is twice as likely to have a relative (first – [parent, siblings and children], second [aunts and uncles] or third degree [cousins]) who also has an ACL tear and more than twice as likely to have a first-degree relative (sibling, partner, or child) with an ACL tear.

As this was one of the first studies to look into this area, much more in-depth studies need to be carried out, looking into diet, geographical location and many other pertinent factors to see why there would be a familial predisposition to this injury.

3.2(e) Ground forces

Orchard *et al*, 1999 and Orchard, J, 2002 have all studied whether ground type could be a possible extrinsic factor for ACL injury. Both studies looked into climatic conditions, looking into rainfall, evaporation and the time of year the injuries were occurring. Orchard *et al,* 1999, used an ongoing surveillance program, analysing 2280 AFL matches, of which there were 111 ACL injuries reported. Most of these injuries occurred north of Melbourne where the evaporation rates were much higher and rainfall levels were much lower. Their results correlated with those found by Orchard, J, 2002, that high water evaporation and low rainfall are related to increased risk of ACL injury. Orchard *et al*, 2005, also continued the research in looking at different grass types to see whether that had an impact on injury rates. The results showed that certain grass types could definitely be a causative factor for ACL injury. They suggest that certain grass types are more appropriate for certain times of the year, during different seasons. Rye grass was suggested as being the most favourable ground surface to use, due to its ability to retain water, leading to low evaporation rates, creating a more favourable ground surface "as blades and cleats of football boots are less likely to be "gripped" by the surface." (Orchard *et al,* 2005)

Studies have also looked into shoe-surface interface and according to Orchard *et al,* 1999, it has been hypothesised for years that increasing traction between football boot and playing surface would cause an increase in the rate of knee injuries. After many famous footballers have incurred the same injury, i.e. fractured 5th metatarsal, suspicion has started to arise as to whether the type of stud worn by the player may be having an effect on the injuries occurring. This is an area that is currently only in discussion and no literature has yet been disclosed in this particular area.

3.3 Classification of Foot type

To be able to diagnose a foot morphology and have the ability to determine the level of severity is key, especially within podiatry, however it is questionable as to whether the techniques used are actually reliable and valid. There are various methods of foot type classification currently available, some of which are considered to be more reliable than others. Podiatrists use methods of foot posture assessments everyday as part of the biomechanical assessment. There are many traditional methods available and each method has been researched and scrutinised and currently there is still no method that provides complete consistency of a measurement or that can guarantee that the results observed would be repeatable by a number of practitioners.

Root *et al*, 1977, through his work and his findings, was able to implement a framework for podiatric assessment of the foot, which was used as the foundation of all biomechanical assessment for a number of years, without question. However, recently researchers have challenged these theories and the assessment techniques that Root *et al,* 1977 put in place have been shown to lack reliability and validity (cited in Evans *et al,* 2003). One of the major flaws recently discovered is that regarding the neutral calcaneal stance position; Elvery *et al*, 1988 quoted, 'The subtalar joint neutral position is the crux of Roots theories, about which all feet are said to optimally function and from which all measurements are made. However this concept has also been a significant barrier to reliability, lacking definition as a starting point for measuring the foot.' (Cited in Evans *et al*, 2003). Due to this theory being questioned, it is inevitable that all methods of foot type measurement, which have been based on roots theory, have all been subject to scrutiny and a re-evaluation of the methods used for assessment of foot type is essential.

Evans *et al*, 2003, investigated the reliability of the Foot posture index and other traditional methods, including, Navicular height, Navicular drop, resting calcaneal stance postion, neutral calcaneal stance position and forefoot to rearfoot measurement. A sample group of all ages and genders was used, 29 children, 30 adolescents and 30 adults. These three groups were analysed separately. Three examiners assessed each child and four examiners assessed each adolescent and adult, using the methods of assessment stated above. From these assessments the results enabled Evans *et al*, 2003 to make assumptions on how reliable the techniques are.

The Foot posture index was one of the main focus points in this study and the results showed that across the different age groups and genders the interrater reliability was generally good, although its was still suggested that further investigation into the reliability of the eight specific criteria examined in the Foot posture index is essential. In children it was only classified as moderate, however this could have been due to the difficulty in analysing the children's feet, due to their reluctance to comply. Evans *et al,* 2003, stated that in an adult foot the most reliable method of measurement was the navicular height assessment. Mathison *et al*, 2004, also found that when he investigated the validity of Staheli arch index, Chippaux-Smirax index and navicular height, navicular height proved to have the greater sensitivity rates and classified it as a valid method. The navicular height assessment method has also been associated with the navicular drop method, however according to Evans *et al*, 2003, this particular method showed poor interrater results, Picciano *et al*, 1993, also reported that his results also supported that of Evans *et al,* 2003 regarding the navicular drop. The results found, were once again contradicted by other studies carried out by Menz*,* H, 1998 and Mueller *et al*, 1993; they found the navicular drop test proved to be one of the most reliable and appropriate techniques. Mathieson *et al*, 2004, recommended that this technique would enable the practitioner to measure excessive pronation, excessive supination and restricted motion in the foot. The other methods of assessment examined in the study carried out by Evans *et al*, 2003 also had poor levels of reliability and validity and that if there was no alternative method available for use, the practitioner must use all these methods of assessment with caution.

In the study carried out by Mathieson *et al,* 2004, they also evaluated the validity of Staheli Arch index and the chippaux-smirak index. They found both these methods were significantly sensitive to discrete alterations in subtaler joint orientation, however the significance was low and it was stated that as foot type could not always be accurately classified using these methods, the use of them should be avoided if possible. Although the reliability of the Staheli arch index method is questionable, McCrory *et al,* 1997, believe that many studies that have deemed it to be unreliable and invalid have many faults in their method and have been too quick off the mark to make such accusations. McCrory *et al*, 1997 believe that the arch index provides a useful measure of arch height (cited in Menz, H, 1998).

There are many other methods of foot type classification, however there is not one particular method that has been categorically proved to guarantee reliability and validity. Currently, unless a new theory or Root's theory behind subtalar joint neutral is proved, the majority of foot type assessments must be used with caution. Further investigations into a reliable method of foot assessment is essential, as the majority of biomechanical treatments carried out by podiatrists are heavily based on the findings from these assessments.

3.4 Foot type and Injury

Foot structure and the incidence of injury in athletes is an area under close surveillance at this present time. Many researchers have identified that there is a significant relationship between the two, however once again the literature is very contradictory when analysing what they found. This could be related to the method used in which to define and categorise arch structure (Williams *et al*, 2001). Some pieces of literature have focused on a certain sport, others certain types of injury and others have concentrated on injuries across different sports, which may be linked to foot type. According to Williams *et al*, 2001, high-arched and low-arched runners with their different bony architecture may exhibit very different lower extremity mechanics and, consequently, different injury patterns.

Kaufman *et al,* 1999, carried out a two-year investigation into the effect of foot structure and range of motion on musculoskeletal overuse injuries. Using a cohort of 449 male trainees, aged between 18 – 29 years old, from the Naval Special Warfare Training Centre, ankle motion and subtalar motion measurements were taken and the characteristics of the foot arch were analysed in a static (standing) and dynamic (walking) position. The arch characteristics of both feet were measured during weight bearing; two different methods of assessing the characteristics of the arch were used. The arch index was measured by using the ratio of navicular height to foot length and the dynamic assessment was carried out using a foot-pressure measurement system, which consisted of a sensor with 960 sensing elements that covered the entire plantar surface of the foot (Kaufman *et al*, 1999). All clinical personnel at the training centre also attended a 2-week course on sports injuries, to optimise the reliability of the diagnoses made. It was noted that there was no significant difference in age, race, height, weight and fitness level. Overall 348 lower extremity injuries were recorded during training, with the most common being stress fractures, iliotibial band syndrome, patellofemoral syndrome, Achillies tendinitis and periostitis. Kaufman *et al,* 1999, found that there was a statistically significant association between pes planus foot type and stress fractures, when assessed dynamically in shoe, however their results also showed that there was a definite increased risk of stress fracture in both the pes planus (pronated) and pes cavus (supinated) foot type, compared with those subjects with a normal arch height. These results almost contradicted those that had been found by Giladi *et al,* 1985, their study showing that the pes cavus foot type and the subjects with a normal arch height were at increased risk of stress fracture injuries compared to those with a pes planus foot type. These results are also consistent with findings made by Simkin *et al*, 1990, which stated that subjects with a high arched foot type were more prone to tibial stress fractures, than those subjects with a low arched foot type.

Kaufman *et al*, 1999, also found that there were no statistically significant findings made with regard to foot structure and iliotibial band syndrome or patellofemoral syndrome. However, in a more recent investigation carried out by Williams *et al*, 2001, they found that iliotibial band syndrome was significant in the high arched group of athletes. Other injuries found to be associated with a HA (high-arched) within this study were plantar fasciitis and lateral ankle sprains, although the injury type was not stated. Burns *et al,* 2005, also found that amongst triathletes, there was a significant increase in injuries to athletes with a supinated foot type. The study carried out by Kaufman *et al,* 1999, appeared to have very few faults in the research. They used two methods of categorising foot type: one in a static position and the other in a dynamic position. However, a more valid method of assessing the arch in the static position could have been used, as many studies that have been carried out in a similar field have used the valgus index along with the foot posture index, these together appearing to be classified as reliable methods of assessment (Burns *et al*, 2005). The cohort study group used was also that of a very strong-minded, highly motivated group of people, who would be unlikely to admit and report injury unless very serious. This aspect could have significantly affected the validity of this investigation (Kaufman *et al*, 1999). There was also the opportunity for false information to be submitted and as the clinical personnel were only given a limited two-week course on how to diagnose the different conditions, there was also a high risk of misdiagnosis.

Williams *et al*, 2001, researched arch structure and injury patterns in runners. They hypothesised that high-arched runners would exhibit greater incidence of lateral injuries, skeletal injuries and knee injuries while low-arched runners would show greater incidence of medial injuries, soft tissue injuries and foot injuries. Their sample consisted of twenty high-arched and twenty low-arched runners, aged 18 – 50 years, with no neurological abnormality or history of foot surgery. The arch ratio of each participant was measured by dividing the arch height from the floor by the individual's foot length. The participants were then asked to complete a questionnaire regarding the history of their lower extremity injuries. Chi-square was used to analyse the data and they found that there was a significant difference between foot type and the injuries incurred. They found that high arched runners were more susceptible to lateral injuries, bony injuries and foot and ankle injuries, whereas low arched runners had more medial injuries, soft tissue injuries and appeared to have more knee injuries.

However the study carried Nigg *et al*, 1993, contradicted those results found by Williams *et al*, 2001, regarding the knee, as Nigg *et al, 1993* found that an increased arch height could significantly be linked to knee pain. Dorsey *et al's* study also was of a good standard, with very few limitations, however the sample size once again was not of a large number and both males and females were used. Using both genders could be seen as a variable factor. The information regarding the injuries was also taken in retrospect and self-reported by the athletes. Although all injuries had been diagnosed by a doctor, the athletes' knowledge of the medical terminology may have be limited and therefore the information submitted may have been inaccurate and possibly altered by recall bias. Foot orthoses could also have been a factor within this study, so therefore, a study carried out on a population who had never been submitted to foot orthoses may have been a better population group on whom to carry out this research.

In conclusion, it is apparent that there is definitely a connection between foot type and sports injury. The evidence has shown that there is a significant correlation between the two factors; however there seems to be a slight conflict in the evidence as to which foot type is more prone to which injury. According to Burns *et al*, 2005, evidence suggests that the pronated foot type is a protective factor against injury, however it has also been reported that the high arched foot type was protective against all injuries in runners (Wen *et al*, 1998.) It is therefore important that further research is carried out in this area, possibly using bigger sample groups and using a cross section of the population from different sports. It may also be important to carry out assessments in shoe, as most injuries are likely to occur in athletes whilst wearing their specified sporting footware. Evidence has also shown that certain footwear can also have an effect on different foot types. Butler *et al*, 2006, carried out two studies and in both found that high-arched individuals were better suited to a cushioned shoe, as this shoe type helped reduce tibial shock, however a low arched foot did not benefit from a cushioned shoe and the results showed that motion control trainers were more suitable for low-arched runners as it helped to decrease tibial internal rotation. Once again further research is needed in this area, but a study carried out on football boots and foot type could be an area for consideration.

4. Methodology

This chapter is a factual account of the plan of the study. For ease of interpretation it has been divided into six sub sections:

4.1 Outline of Method

4.2. Sample Group

4.3 Instrumentation

4.4 Ethical Approval

4.5 Procedure

4.6 Analysis of Data

4.1 Outline of method

- A quantative method was used for this particular research study.

- A letter was sent out to various football clubs and individuals requesting the participation of football players who had suffered an anterior cruciate ligament (ACL) injury and football players who had not had any previous injury to their ACL.

- A sample of 50 football players took part in the research, all males and also of mixed ability, ranging from amateur to professional level and aged between 17 and 35 years.

- A consent form was sent out to each participant 24 hours prior to the research participation starting. **(Appendix 1)**

- The participants were also asked to complete a questionnaire.
(Appendix 2 and 3)

- Each participant was then asked to step barefooted onto the Bailey's pressure stat, giving an imprint of the footballer's foot.

- Staheli arch index was used to classify the foot type of the participant.

- The results were then to be analysed using chi-square, to see if there were any correlations between anterior cruciate ligament injuries and foot type.

4.2 Sample Group

The sample group used consists of all male footballers from all levels of the game, ranging from amateur to professional. They all fall within 'normal' weight range for their height **(See appendix 4).** The sample group consisted of 50 football players in total, half of whom had experienced anterior cruciate ligament injury and the other half being the control group, having had no injury to their anterior cruciate ligament throughout their career in football. All participants were active sportsmen between the ages of 17 – 35 years.

It had been my original intention to include females within this study, however there is some research indicating that females are more susceptible than males to this injury and I did not want this factor to interfere with my results.

Ideally a larger sample group would have been used, however, due to a limited time scale and factors which were unforeseen by the researcher, the sample group used had to be reduced.

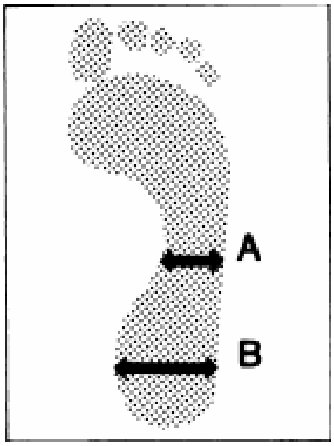
4.3 Instrumentation

The researcher decided to use to different techniques to try and gain the information required for this particular study. A questionnaire was devised using both open and closed questions for the participants who had suffered an ACL injury. A different questionnaire was devised using similar questions to that in the ACL injured participant questionnaire for the football players who had never suffered an ACL injury.

The questionnaire was devised after having read through many pieces of literature and the questions asked endeavoured to try and counteract as many variables as possible, which had been found to affect previous study results, such as the type of football boot worn during the injury.

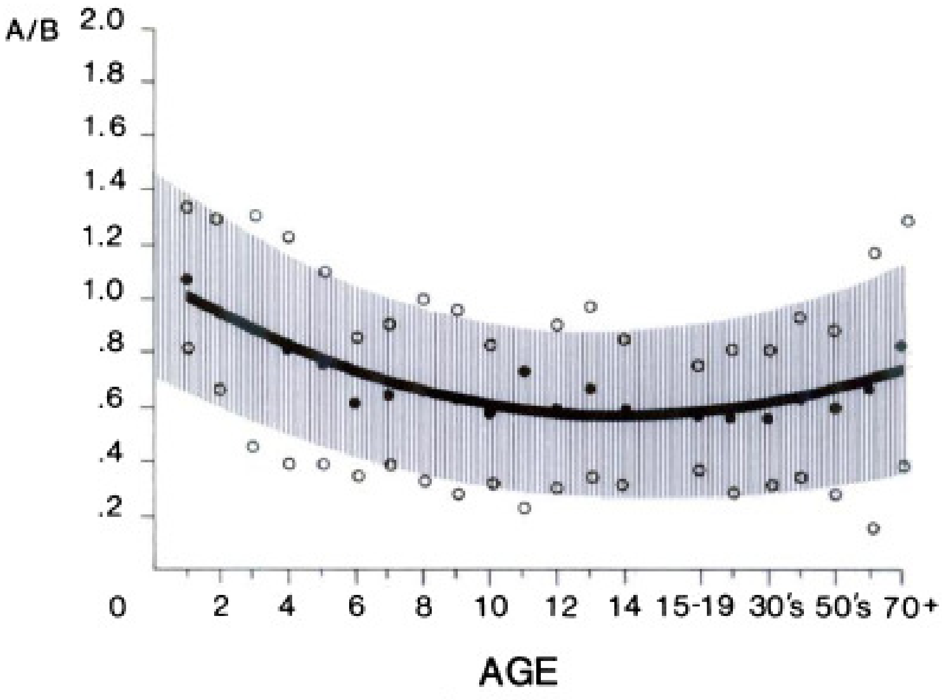
A Bailey's pressure stat was also used with each participant to take an imprint of the foot. This particular pressure stat is generally used on diabetic patients to measure the main pressure areas of the foot whilst in closed kinetic chain. However, the researcher felt this was the ideal instrument to use, as it was clean, quick and it was remarkably easy to use to calculate the Staheli Arch Index of each footprint. This method of measurement was chosen because of the need to make the testing fast in order to encourage more footballers to participate in the research. This form of testing was also less complicated and the cost was considerably lower than the more technical methods of measuring foot type.

The Staheli arch index (Staheli *et al,* 1987) is a method of measuring the longitudinal arch of the foot using a footprint. From this you can determine whether the foot is in a neutral, pronated or supinated position, by dividing the thinnest part of the lateral border of the foot by the widest part of the heel.



(Staheli *et al*, 1987)

According to Staheli et al, 1987, the arch index has a broad normal range from about 0.30 to 1.0 throughout adulthood. Normal values for 18 – 30 year olds would be between 0.6 – 0.7 and this is represented by the two solid circles on the graph.



(Staheli *et al*, 1987)

For the purpose of this study, the foot type will be classified based on the values suggested by Hogan and Staheli, 2002. When the value is closer to zero it represents a high arched foot type (pes cavus) and when the value is closer to one it represents a more pronated foot type (pes planus). Where the value is less than 0.59 the foot type will be classified as supinated, where the value is found to be between 0.6 – 0.7 the foot will be classified as normal and where the value is more than 0.71 the foot will be classified as pronated.

The foot posture index, (Evan *et al*, 2003) was also considered as a method of classifying the foot type, however due to time constraints, and as the whole research was carried out on busy footballers, the researcher had to make sure that the method used would not take up too much time.

4.4 Ethical approval

Ethical approval for this study was provided by the School of Health Ethics Committee at the University of Northampton

4.5 Procedure

After the researcher had gained ethical approval the research could then begin. Both questionnaires were devised and were certified by the researcher's tutor. As the researcher's proposal to the ethical team had stated many guidelines that would be followed to ensure a safe and ethical piece of research, it was important that these guidelines were followed throughout the study.

- All participants to be informed and educated about what the research entails before they participate, to ensure that the research is ethically sound
- A consent form to be sent out to each participant at least 24 hours before the research takes place
- All participants to be given the right to withdraw from the study at any time.
- All participants to remain anonymous throughout the procedure
- All information gathered to remain confidential
- A chaperone to assist the researcher during data collection

Initially letters were sent out to various football clubs and individuals playing at various levels across the country to see whether they would be interested in participating within the study. After numerous replies, participant information sheets with a consent form attached were sent to the various footballers interested. Contact was only made through e-mail for ethical reasons and, through this method, dates were set with each individual and various teams for the research to take place. This, in some cases, was difficult due to football fixtures and other commitments and in many cases the dates were cancelled and re-arranged. This unfortunately led to set backs in the time schedule and also regrettably ended in failure to include some crucial players within the research.

The actual data collection procedure was relatively simple and fast, the time spent with each player being approximately 4 minutes. During this time the participant completed the appropriate questionnaire in order that the researcher gain some background knowledge of the injury and also the player's background football history. The player then proceeded to stand on the pressure stat barefooted with the leg that had suffered the ACL injury. If the participant had not experienced such an injury, the foot used was that of the leg most prone to previous injury. It is also important to note that if the participant had suffered an ACL injury to both knees, an imprint of both feet was taken.

There was no specific location used, and the only variable that needed to be kept consistent was the type of ground surface on which the participant stood on the pressure stat and it was important that a solid ground, e.g. concrete, was used to avoid any differences in ground force contact, which may have affected the footprint taken.

After all the information had been gathered it was collated and the researcher used the Staheli Arch Index and measured the foot type against the table of values suggested by Hogan and Staheli, 2002

4.6 Analysis of data

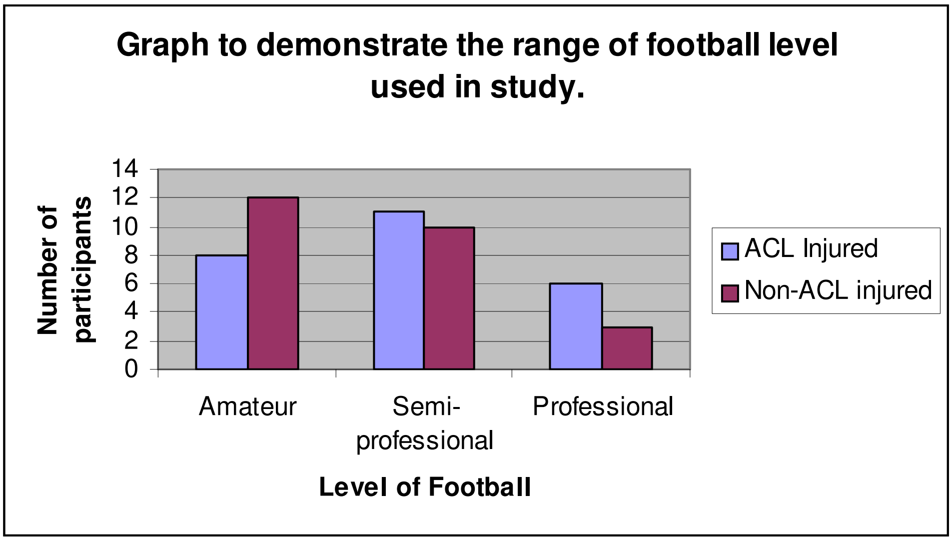
A quantitative approach was used within this study and therefore data analysis was carried out using SPSS. As the information gathered was categorical data, the statistics were analysed using the chi-square test, to see if there was any significant correlation between foot type and ACL injury.

Qualitative data had also been collected from the questionnaire and this information has been displayed in bar charts and pie charts produced using Microsoft Excel. This information has not been statistically analysed and has only been included for the sole purpose of eliminating variable factors.

5. Results

A total of 50 male footballers participated in the study, 25 of whom had incurred an ACL injury, and the remaining 25 never having incurred an ACL injury. The football players used were all of mixed football level, ranging from amateur through to professional.

Graph 1



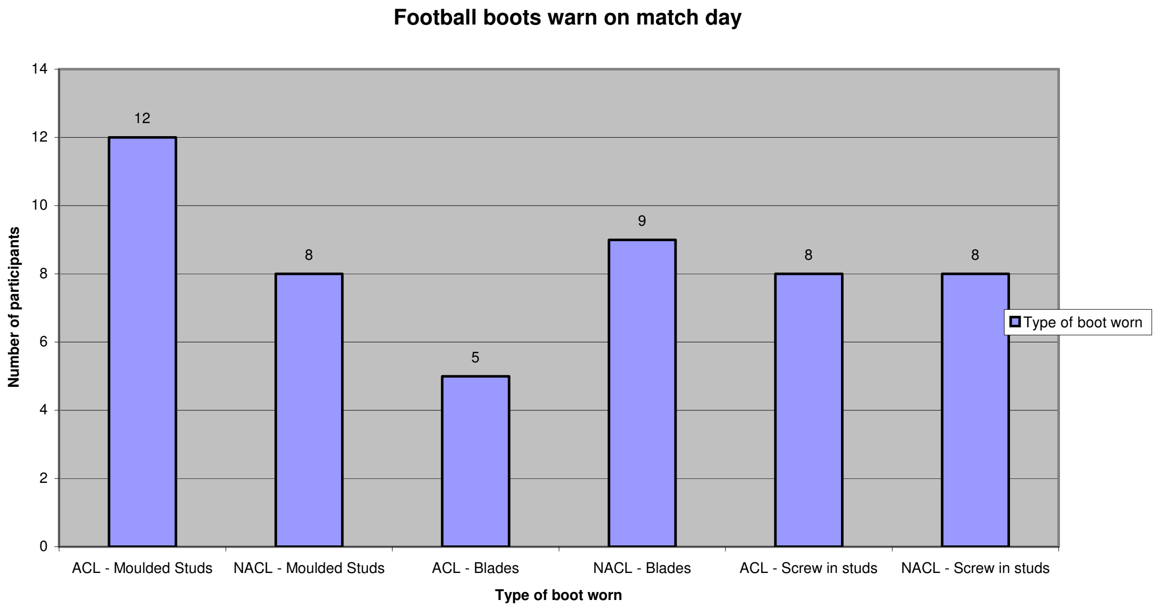
Before looking at whether there is a connection between foot type and ACL injury, it is important we analyse the information gained from the questionnaire, completed by each participant. The aim of the questionnaire was to eliminate any possible variable factors that may have influenced results in previous studies.

5.1 Influencing Factors

Type of football boot worn

The first graph will look at the boots worn by all the participants on match days;

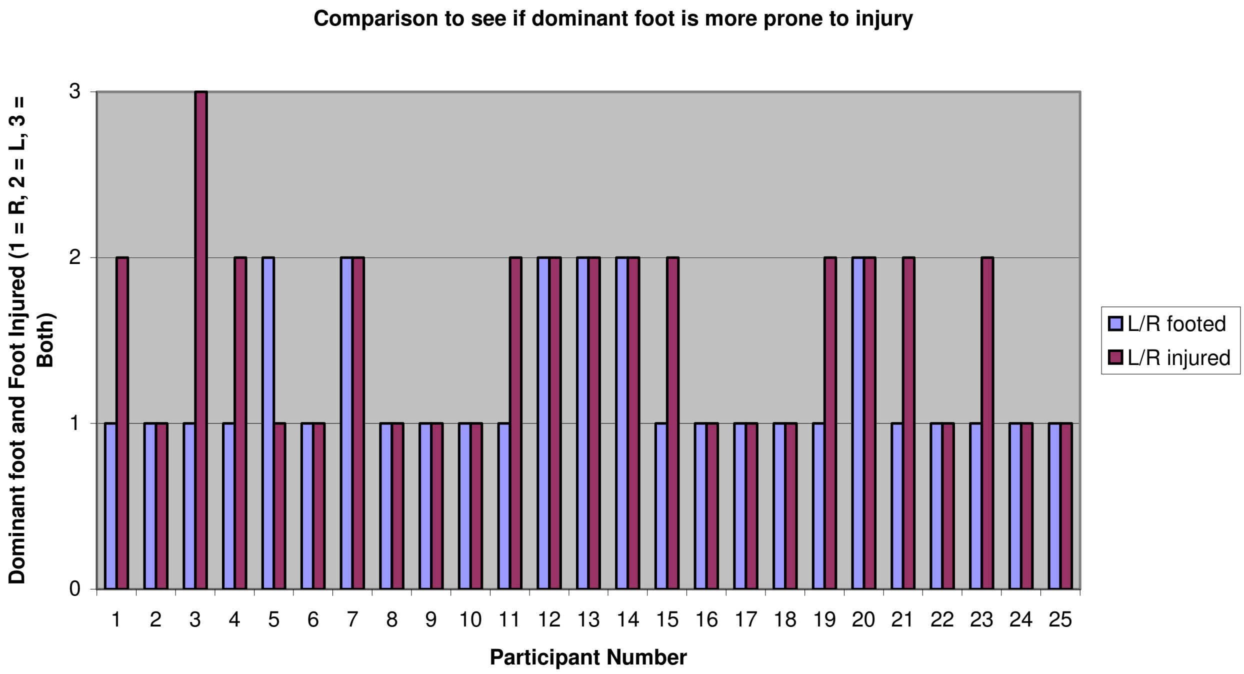
Graph 2



Dominant foot and injury

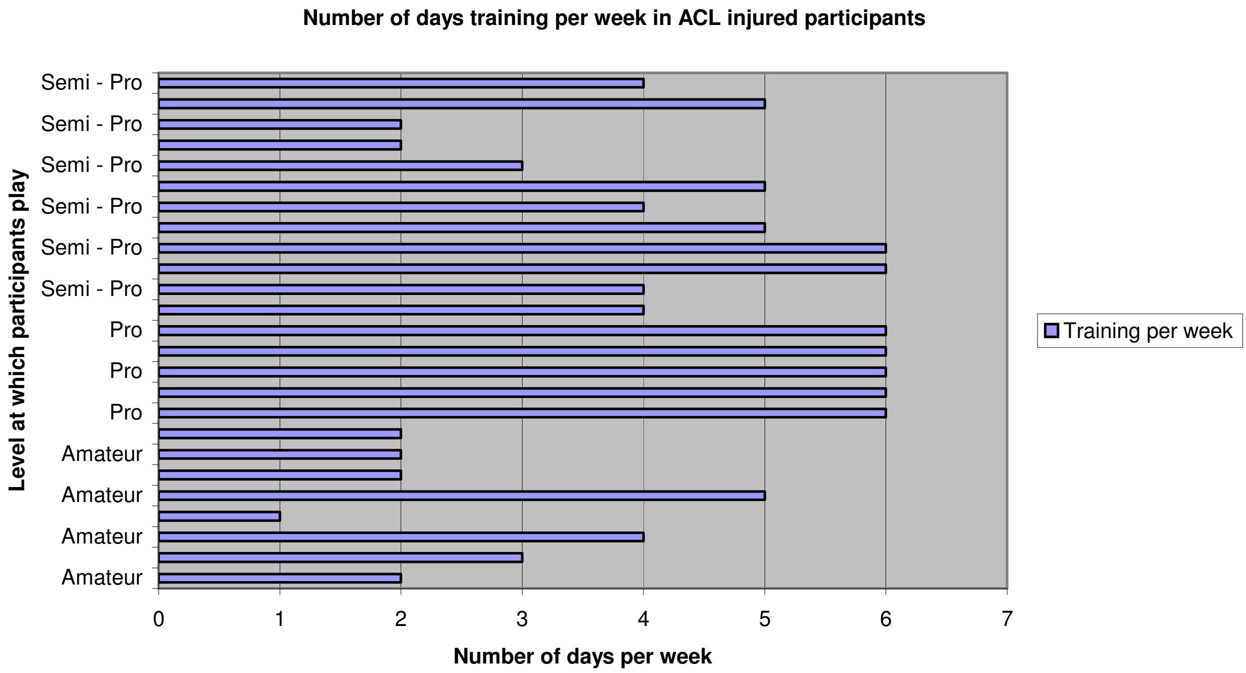
Secondly it was important to see if there was any correlation between their dominant foot and the leg to which they sustained the injury.

Graph 3



Training per week

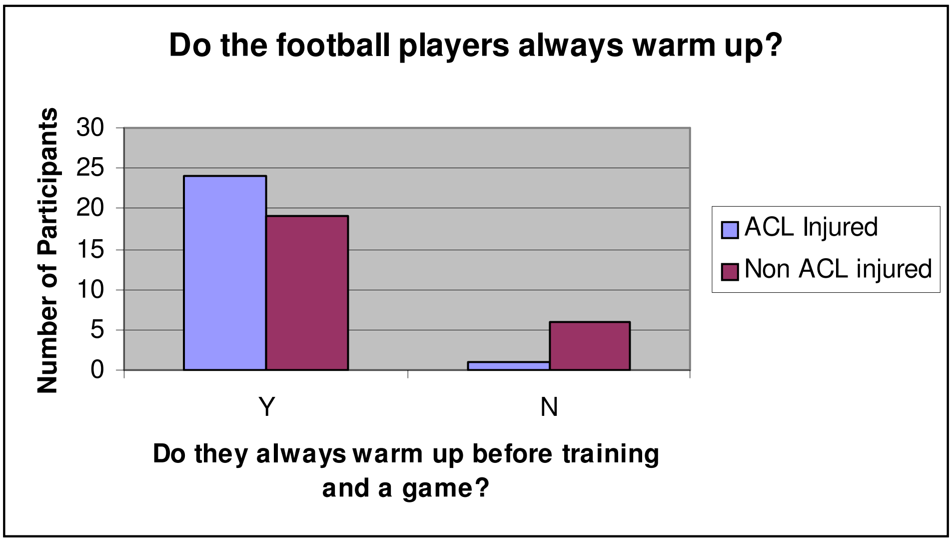
Graph 4



Warming up before a game

The following graph demonstrates the number of participants that do and do not always warm up before training and a game in the participant both with and without ACL injury

Graph 5



Height, Weight and Age

The mean value of height, weight and age amongst the participants used has been shown in the table below:

Table 1

	Mean Height	Mean Weight	Mean Age
ACL injury	5ft 11in	12st 5lbs	23
Non-ACL injury	5ft 9in	12st 7lbs	23

5.2 Is there a correlation between foot type and ACL injury?

As all the information from the questionnaires has now been evaluated, eliminating many of the possible variable factors, we are now able to analyse, using statistical methods, the results, using Pearson's chi –square test to see if the three hypotheses stated have been accepted or denied.

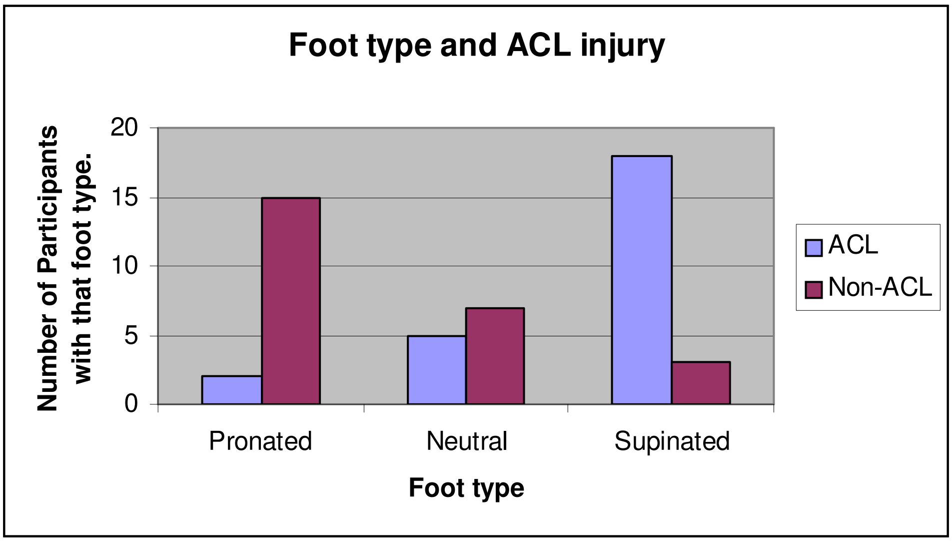
Below is a table demonstrating the number of participants with each foot type:

Table 2

Foot type	Pronated	Neutral	Supinated
ACL injury	2	5	18
Non-ACL injury	15	7	3

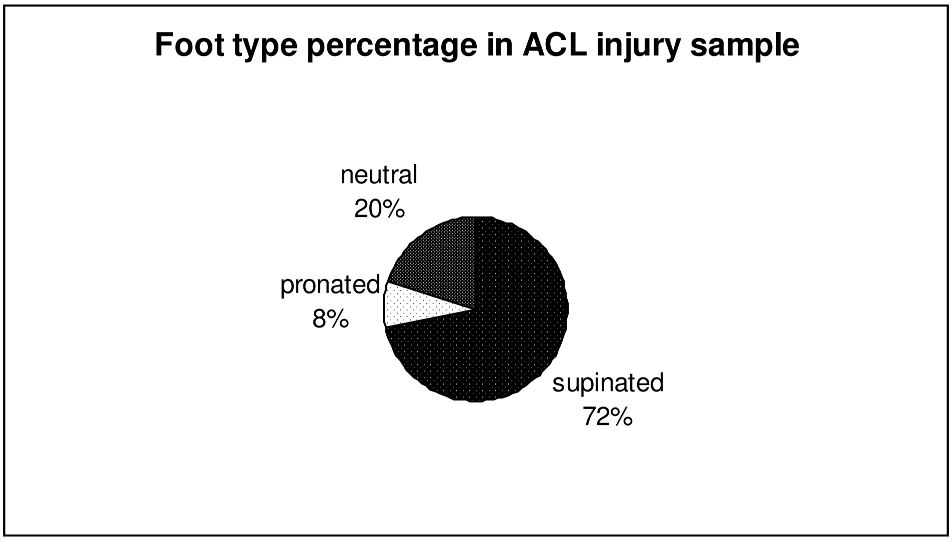
The graph below shows the overall relationship between foot type and ACL injury:

Graph 6



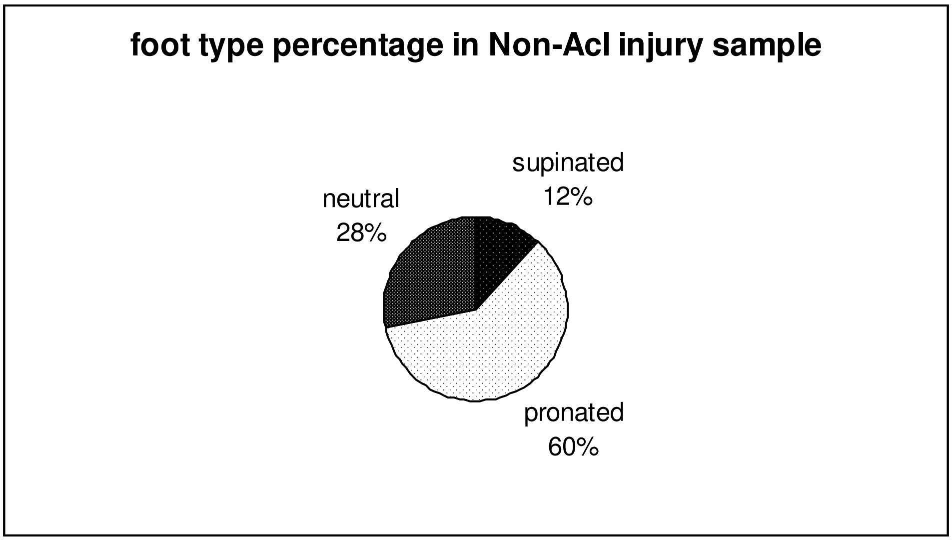
Graph 7

Below is a pie chart that shows the percentage of foot types in the football players used in the study with an ACL injury:



Graph 8

The pie chart below shows the foot type percentage levels found in the control group used.



Pearson's Chi-square test

Three Chi-square statistical tests were carried out, looking at the relationship between pronated foot type and ACL injury, neutral foot type and ACL injury and supinated foot type and ACL injury.

Pronated foot type and ACL injury

A Pearson's Chi-Squared value of 0.000 was calculated, showing that the results are statistically significant. For the results to be significant the P-Value must the same as or less than 0.05.

The degree of freedom calculated in this test was 1.

(See Appendix 5)

Neutral foot type and ACL Injury

A Pearson's Chi-squared value of 0.508 was calculated, showing that the results are not statistically significant.

The degree of freedom calculated in this test is 1.

(See Appendix 6)

Supinated foot type and ACL injury

A Pearson's chi-squared value of 0.001 was calculated, showing that the results are statistically significant. These results show that there is a significant correlation between ACL injury and a supinated foot type.

The degree of freedom calculated in this test is 1.

(See Appendix 7)

6 Discussion

For ease of analysis and interpretation, the researcher has chosen to divide this section into 3 consecutive parts.

6.1 Analysis of results

6.2 Relationship of results with literature

6.3 Methodology critique

6.1 Analysis of results

Quantitative Data

Three experimental hypotheses were designed for this study to determine whether or not there was a correlation between a certain foot type and ACL injury. Using Pearson's Chi-square, a supinated foot type was shown to be significantly more prone to ACL injury, compared with a pronated foot type, which appeared to be the more favourable foot type in those footballers who had never incurred an ACL injury. Two of the hypotheses declared were classified as statistically significant and therefore were accepted, however the hypothesis that there would be a correlation between a neutral foot type and ACL injury was rejected as the results were not statistically significant. Amongst the football players used there was also only a small proportion of players with a neutral foot type and therefore the sample group used for this particular foot type was too small to even propose that there may have been correlation.

Pronated foot type and ACL injury – chi-square test

The P-Value calculated in this test was 0.000. These results show that there is a significant correlation between non-ACL injury and a pronated foot type. These results reject the statistical hypothesis that the variables are independent and represent the hypothesis that there is a relationship between the variables. The hypothesis that there will be a correlation between pronated foot type and non-ACL injury has been accepted.

Neutral foot type and ACL injury

The P-Value calculated in this test was 0.508. These results show that there is no correlation between a neutral foot type and ACL injury. Therefore the statistical hypothesis that the variables are independent can be accepted, meaning that the researchers hypothesis has been rejected.

Supinated foot type and ACL injury

The P-Value calculated in this test was 0.001. These results reject the statistical hypothesis that the variables are independent and represent the hypothesis that there is a relationship between the variables. The hypothesis that there will be a correlation between supinated foot type and ACL injury has been accepted.

When looking at Graph 6 in the results section, one is able to see the significant difference in the foot types between the ACL injured group compared with the control group. The pie charts also demonstrate the percentage of footballers who have a certain foot type. The difference is quite substantial when comparing the percentage of players with a supinated foot type in the ACL injury (72%) group against the control group (12%). There is also a significant difference when comparing the percentage of the pronated foot type in the non-ACL injured group (60%) against the percentage of the pronated foot type in the ACL injured group (8%).

Therefore the two hypotheses to be accepted at a statistical level are:

1. There will be a significant correlation found between supinated foot types and ACL injury.
2. There will be a significant correlation found between pronated foot types and non-ACL injury.

Qualitative Data

One of the major flaws in research focusing on sporting injuries is that there is a huge area open to error, as there are many variable factors that could predispose, or even contribute, to an athlete's risk of injury. Therefore it is important to try and eliminate as many of these factors as possible when carrying out a piece of research, in order to ensure that the results found will be guaranteed to be significant and without limitations.

Two questionnaires were used in this study: one focusing on footballers with an ACL injury and the other focusing on the football players who had not incurred an ACL injury. The variable factors analysed using the questionnaires were: the types of football boot worn, whether there was an association between the dominant foot and the leg that suffered the ACL injury, whether or not the players always warm up before training and a game and whether the players had a similar training regime. Their height, weight and age were also taken into consideration.

When looking at the graphs in the results section one can see that in many of the cases, the factors that have been suggested to influence results in previous studies, have now been eliminated as variable factors for this particular piece of research.

Discussion on the graphs and tables.

Graph 2 (Type of football boot worn)

The results show that there is not one favoured type of boot worn. ACL injuries have also not ocurred more frequently when participants have been wearing one type of boot compared to another.

Graph 3 (Dominant foot type and ACL injury)

From the results, it is apparent that the majority of ACL injuries did occur in the same leg of which that foot is the most dominant. This is an area in which research needs to be carried out, as currently no research has focused on this area when looking into this particular injury. As the results show that there could be a link, this must be taken into consideration, when linking ACL injury to a supinated foot type. Bearing in mind the fact that the dominant foot appears to be more prone to injury, if further research were to be carried out in this area it may be important to consider also whether the foot was planted in the ground at the time of injury or kicking the football.

Graph 4 (Training per week)

It was important to investigate if the amount of time a player trained in a week could possibly influence an ACL injury. However, from the results it is apparent that across the various levels at which the participants play, there appears to be no pattern in the number of days each participant trained. Every participant who had sustained an injury trained at least once a week, those at a higher level having a much more intensive training regime, which was to be expected. There is no significant pattern occurring in this chart that would suggest the amount of time a player trained per week could influence an ACL injury.

Graph 5

It is strongly believed that by not warming up before participating in sport one is more prone to injury. The results show that the majority of participants do warm up, so this is therefore unlikely to be an influencing factor in ACL injury in this particular sample group.

Table 1

Using the table of values suggested by the US diet guidelines **(Appendix 4),** the researcher ensured that all participants used were within the acceptable weight range for their height. The mean height and weight of all the participants was calculated and was well within the acceptable range, therefore eliminating weight as a risk factor for ACL injury in this particular study.

In summary, it can be said that two of the hypotheses have been accepted and the results can therefore be deemed as statistically significant. Foot type could be an influential factor in anterior cruciate ligament injuries.

6.2 Relationship of results with literature

Following analysis of the results, it can be said that a supinated foot type is more prone to ACL injury than the pronated foot type. Recent literature has also discovered similar findings, suggesting that a supinated foot type is more prone to certain injuries. Burns *et al*, 2005, found a significant correlation between supinated foot type and sustaining an overuse injury. They stated that a supinated foot type was 4.3 times more likely to incur an injury compared with those without a supinated foot type. Giladi *et al*, 1985, also found in a study carried out on military recruits that a high arched foot type was much more likely to develop stress fractures compared to low arched foot types. These findings were also confirmed in Cowan *et al's* study, 1993, which found that within a group of army infantry trainees in the United States, high-arched individuals were at an increased risk of lower-limb injury than those with a low arched foot type.

One study that agrees with the findings in this study, regarding the link between the supinated foot type and knee injury is the research carried out by Nigg *et al*, 1993. According to these researchers, there is a functional association between arch height and knee injury. They suggested that this may be due to the transfer of foot eversion to internal leg rotation and this was found to increase significantly with an increasing arch height. It is important to note that, due to the method used for assessing the foot type within this particular piece of research, no consideration was given to the biomechanical abnormalities above the ankle, therefore tibial varum, tibial torsion etc was not evaluated in the assessments nor taken into consideration when analysing the results.

Nachbauer and Nigg, 1991, quoted that, Cowen *et al,* 1989 had found that, 'Flat feet, frequently associated with overpronation, are not a risk factor for injuries and suggested that they may even be protective.' The results found in this study support this theory within ACL injury, that a pronated foot type could be a protective factor against ACL injury, however after analysing the questionnaire data collected from the control group, the pronated foot type is still prone to other lower limb injuries, such as lateral ankle sprains. According to Hopper *et al*, 1994, ankle injuries are of the most common within netball and basketball and the most serious type of injury is that to the knee. Both these injuries have been identified in this study on ACL injury. The statement made by Cowen *et al,* 1989, was disputed by Wen et al, 1998, when it was stated that a high arch foot type was considered a protective measure against all injuries in runners.

Hopper *et al,* 1994, carried out a study on elite netball players. The results found contradicted those that were found to be significant in this study; they found that the pronating foot types were more susceptible to injury, especially when compensating for rear foot varus. They found that the most common injuries were both to the ankle and the knee. However, the foot type was measured using the neutral and relaxed calcaneal stance position assessment to measure the degree of pronatory or supinatory compensation. This method of measurement is currently under great scrutiny and according to Evans *et al*, 2003, is extremely unreliable and repeatability of results between examiners is very poor. Evans *et al*, 2003, also suggested that this form of assessment should be used with great caution as it has been classified as an unreliable method. Therefore the results found by Hopper *et al*, 1994 could be considered to be invalid. Beckett *et al,* 1992, however also found that participants in their study who had suffered an anterior cruciate ligament injury had a greater navicular drop (pronated foot type) than those who had no history of injury, suggesting that there is a strong possibility that there is a connection between excessive pronation of the foot and ACL injury. Those results once again completely contradict those found in this piece of research.

As all the methods of foot type assessment have been shown to have limitations and are currently under great critical analysis, it is important to note that all the evidence found within this research area could be considered to be unreliable. The research that has used two or more methods of foot type assessment reduces the opportunity of the results being due to chance. This is not to say however that all the significant results are flawed, as many of the methods of assessment do have statistical significance. Nevertheless, in order to eliminate limitations and to ensure that statistical significance is guaranteed when future research is carried out, both foot type analyses and comparison of foot type should be considered.

6.3 Methodology critique

Following analysis of the results it can be said that that a supinated foot type is more susceptible to anterior cruciate ligament injuries than a non-supinated foot type. However, previous literature and the results found contradict those results found in this particular study, with regard to whether foot type is an implication to injury, leading the researcher to question why this may be. According to Williams *et al*, 2001, ‘Differences in results of all the studies may be related to the method of defining and categorising arch structure.’

Footprints were used to measure the foot type in this current study, using a Bailey’s pressure stat. This procedure was extremely quick and easy to use and the cost of using a Bailey’s pressure stat was considerably less than that of electronic footprints obtained by pressure platforms etc. The final results for the footprints were very clear and substantial enough for the researcher to calculate the Staheli arch index measurements needed. It was also proved by Urry and Wearing, 2001, that the electronic footprints are not as reliable or representative as those taken using the traditional way of ink footprints.

The ideal method of foot type assessment would have been to analyse the foot type using a number of methods, possibly combining the foot posture index (Evans *et al*, 2003), a full biomechanical assessment and also footprint analysis. This would have given a much larger set of results and would have provided much more validity. The foot posture index and a full biomechanical assessment would have allowed the researcher to notice any abnormalities that would not show on a footprint. Williams *et al,* 2001, found that genu valgum is often seen in individuals with a pronated foot type and may stress the medial structures of the knee. If the other two forms of assessment had been carried out, tibial varum, genu valgum and other biomechanical morphologies would have been noted and possibly further findings may have been discovered to support the results found to be significant in this study. The foot posture index (Evans *et al*, 2003) would have been the researcher's first choice of assessment, as it has been shown to have moderate to good levels of reliability (Evans *et al*, 2003). However due to time constraints and as the whole research was carried out on busy footballers, the researcher had to make sure that the method used would not take up too much time, so the use of foot posture index and a full biomechanical assessment were out of the question. However, if further research were to be carried out in this area, the foot posture index should definitely be taken into consideration and depending on time limitations, a full biomechanical evaluation would provide the information needed to gain significant results.

This piece of literature is not without its limitations, although many of the variable factors suggested to be a problem in previous studies have been eliminated. However, after careful consideration there are also other factors that may have significantly influenced the results. To eliminate further variable factors, the questionnaire would have to be modified. Other variable factors may have been:

- Was it a contact or non-contact anterior cruciate ligament injury?
- Did the injury occur during practice or during the football match?
- Was the participant wearing orthoses at the time of injury?
- What position did the footballer play?
- Did the injury occur in the first or second half of the game?
- What time of year did the player incur the injury?

- Was the foot planted or kicking the ball when the ACL injury was incurred?

All these questions above could have influenced the results found in this study, leaving the results subject to question.

The information gathered for this study was retrospective, so it is important to consider that after the passage of time the players' recollection may be impaired. It is human nature to recall events with a bias in favour of oneself and so, even with the best of intentions, memory can sometimes be unreliable. The medical knowledge of most players would be limited and so the terminology used may not necessarily be precise or accurate.

A prospective study would be ideal to gain factual information, although for this particular injury a prospective study type would be almost impossible and impractical in most cases. If the study were to be carried out again, an imprint of both feet should be taken because some people may be asymmetrical and the imprint from one foot may not demonstrate the same foot type as the other.

This study has also only focused on one demographic group and that is male footballers. In further research, the study should be carried out on various athletes who compete in various sports where ACL injury is a predominant risk factor. The results would then represent a cross section of the sporting population. The study also focuses on males only, so it could be seen as gender bias, however literature states that females are more prone to anterior cruciate ligament injuries. The reasons for this are not yet understood, however there is a strong suspicion amongst researchers that is may be linked to the menstrual cycle. Many studies have been and continue to be carried out in this area, however so far all theories that have appeared to be significant (Wotjs *et al*, 1999), have then been contradicted by another piece of literature (Belanger *et al*, 1999). Due to these suspected additional predisposing factors in females, it was important they were eliminated from this study, as they may have been a variable factor. Further research into why females are more prone to the injury needs to be carried out, so that future research on foot type and ACL injury can then include both males and females in the study.

Another limitation in this study was the relatively small sample size of 50, with only 25 having suffered an ACL injury. This was due to the difficulty in getting participants to take part. The researcher's aim was to get at least 30 participants with an ACL injury, however due to unforeseen circumstances, appointment cancellations with football teams and a constrained time limit, the researcher was restricted in the overall number of participants used in the study. If another study were to be carried out in this area, a longer time scale would definitely be needed, possibly two years, which would allow the researcher to contact as large a cross-section of sports teams as possible and allow the researcher time to work around the sportsmen's busy schedules of fixtures. A larger sample size would ensure adequate statistical power.

In summary, the results from this study appear to correlate with other studies, which have been conducted in this subject area. Within this study the Staheli arch index method appeared to be reliable and assisted in achieving statistically significant results and the values calculated from using this method were easy to categorise into groups of high arch, low arch and neutral foot types. With tighter controls on variables and a secondary line of foot type assessment, it is felt that this piece of research, or one similar, could be a productive focus point for helping construct a model of prevention against ACL injuries in certain foot types.

7 Conclusion

With injury being on the increase, preventative methods are vital and any research that highlights or eliminates factors that may contribute to such injuries are of great importance in this field.

The conclusions to be drawn from this dissertation are that footballers with a supinated foot type are at risk of ACL injury. These significant findings were calculated using the chi-squared test showing a P-value of 0.001. The results also demonstrate that participants who have not incurred an anterior cruciate ligament injury, generally have a pronated foot type, these results being even more statistically significant showing a P-Value of 0.000. Even though the footprint technique proved reliable and provided significant results, the reliability of this technique is still under great scrutiny and so for future research it may be beneficial to use a more established method of assessment to interpret a person's foot type, one that comprises both great validity levels and reliability levels.

The researcher feels that all the aims of the investigation were met and that it is important that research continues in this area to eliminate all variable factors, hopefully highlighting the problem areas so that a model of prevention can start to be put in place. As this research suggests that supinated foot types are more prone to anterior cruciate ligament injury, orthotic therapy is an area that should be considered. If football players were assessed from a young age and before every season they could be prescribed orthoses as appropriate and this, in the long term, could prevent anterior cruciate ligament injuries later in their sporting life, reducing the time a player is out of sport due to the injury and the reduction in medical costs worldwide would be substantial.

References

AGOSTA, J. (1993) Biomechanics of Common Sporting Injuries. In: Brukner, P & Khan, K. (eds) *Clinical Sports medicine*. Sydney: McGraw-Hill companies. pp. 50-51

ANGELO, R. C. O., MORAES, S. R. A., SURUAGY, L. C., TASHIRO, T. & COSTA, H. M. (2004) Morphometric study of the femoral intercondylar notch of knees with and without injuries of anterior cruciate ligament (ACL), by the use of software in digitalized radiographic images. *Acta Ortopdica Brasileira,* 12**,** 146-154.

BAHR, R. & KROSSHAUG, T. (2005) Understanding injury mechanisms: a key component of preventing injuries in sport. *British Journal of Sports Medicine,* 39**,** 324-329.

BARATTA, R., SOLOMONOW, M., ZHOU, B. H., LETSON, D., CHUINARD, R. & D'AMBROSIA, R. (1988) Muscular coactivation. The role of the antagonist musculature in maintaining knee stability. *The American Journal of Sports Medicine,* 16**,** 113-122.

BECKETT, M. E., MASSIE, D. L., BOWERS, K. D. & STOLL, D. A. (1992) Incidence of hyperpronation in the ACL injured knee: a clinical perspective. *J Athl Train,* 27**,** 58-62.

BEESON, P & NESBITT, P. (1995) The paediatric patient. In: Merriman, L. M. & Turner, W. (eds) *Assessment of the Lower Limb.* London: Chruchill Livingstone. pp. 360-361,

BELANGER, M. J., MOORE, D. C., CRISCO III, J. J., FADALE, P. D., HULSTYN, M. J. & EHRLICH, M. G. (2004) Knee Laxity Does Not Vary With the Menstrual Cycle, Before or After Exercise. *American Journal of Sports Medicine,* 32**,** 1150-1157.

BONCI, C. M. (1999) Assessment and evaluation of predisposing factors to anterior cruciate ligament injury. *J Athl Train,* 34**,** 155-164.

BROOKS, J. H. M., FULLER, C. W., KEMP, S. P. T. & REDDIN, D. B. (2005) Epidemiology of injuries in English professional rugby union: part 1 match injuries. *British Journal of Sports Medicine,* 39**,** 757-766.

BURNS, J., KEENAN, A. M. & REDMOND, A. (2005) Foot Type and Overuse Injury in Triathletes. *Journal of the American Podiatric Medical Association,* 95**,** 235-241.

BUTLER, R. J., HAMILL, J. & DAVIS, I. (2006) Effect of footwear on high and low arched runners' mechanics during a prolonged run. *Gait Posture*.

COLLINS, A. (2005) Height Weight Table. *US diet guidelines.* Available from: www.annecollins.com.

COWAN, D. N., JONES, B. H. & ROBINSON, J. R. (1993) Foot morphologic characteristics and risk of exercise-related injury. *Arch Fam Med,* 2**,** 773-777.

COWAN, D., JONES, B. & ROBINSON, J. (1989) Medial longitudinal arch height and risk of training associated injury. *Med. Sci. Sports Exerc,* 21, Citied in NACHBAURER, W. & NIGG, B.M. (1992) Effects of arch height of the foot on ground reaction forces in running. Medicine and Science in Sports and Exercise, 24, 1264 - 1269.

CROSS, M. (1998) Anterior cruciate ligament injuries: Treatment and Rehabilitation [online] Sydney: *North Sydney Orthopaedic and Sports Medicine Centre.* Available from: www.sportsci.org/encyc/aclinj/aclinj.html [Assessed 19th April 2006].

DAHLE, L. K., MUELLER, M., DELITTO, A. & DIAMOND, J. E. (1991) Visual assessment of foot type and relationship of foot type to lower extremity injury. *J Orthop Sports Phys Ther,* 14**,** 70-74.

DEITCH, J. R., STARKEY, C., WALTERS, S. L. & MOSELEY, J. B. (2006) Injury Risk in Professional Basketball Players: A Comparison of Women's National Basketball Association and National Basketball Association Athletes. *The American Journal of Sports Medicine,* 34**,** 1077-1083.

ELVERU, R. A., ROTHSTEIN, J. M. & LAMB, R. R.(1988) Methods for taking subtalar joint measurements: a clinical report. *Phys Ther*, 68, 678, Cited in EVANS, A. M., COPPER, A. W., SCHARFBILLIG, R. W., SCUTTER, S. D. & WILLIAMS, M. T. (2003) Reliability of the Foot Posture Index and Traditional Measures of Foot Position. *Journal of the American Podiatric Medical Association,* 93**,** 203-213.

EMERY, C. A., MEEUWISSE, W. H. & HARTMANN, S. E. (2005) Evaluation of Risk Factors for Injury in Adolescent Soccer: Implementation and Validation of an Injury Surveillance System. *American Journal of Sports Medicine,* 33**,** 1882-1891.

EVANS, A. M., COPPER, A. W., SCHARFBILLIG, R. W., SCUTTER, S. D. & WILLIAMS, M. T. (2003) Reliability of the Foot Posture Index and Traditional Measures of Foot Position. *Journal of the American Podiatric Medical Association,* 93**,** 203-213.

FLYNN, R. K., PEDERSEN, C. L., BIRMINGHAM, T. B., KIRKLEY, A., JACKOWSKI, D. & FOWLER, P. J. (2005) The Familial Predisposition Toward Tearing the Anterior Cruciate Ligament: A Case Control Study. *American Journal of Sports Medicine,* 33**,** 23-27.

GILADI, M., MILGROM, C., STEIN, M., KASHTAN, H., MARGULIES, J., CHISIN, R., STEINBERG, R. & AHARONSON, Z. (1985) The low arch, a protective factor in stress fractures. *Orthop Rev,* 14**,** 709-712.

GIZA, E., MITHOFER, K., FARRELL, L., ZARINS, B., GILL, T. & DRAWER, S. (2005) Injuries in women's professional soccer* Commentary. *British Journal of Sports Medicine,* 39**,** 212 - 216.

GRIFFIN, L. Y., AGEL, J., ALBOHM, M. J., ARENDT, E. A., DICK, R. W., GARRETT, W. E., GARRICK, J. G., HEWETT, T. E., HUSTON, L. & IRELAND, M. L. (2000) Noncontact Anterior Cruciate Ligament Injuries: Risk Factors and Prevention Strategies. *Journal of the American Academy of Orthopaedic Surgeons,* 8**,** 141-150.

HAWKINS, R. D. (1999) A prospective epidemiological study of injuries in four English professional football clubs. *British Journal of Sports Medicine,* 22**,** 196-203.

HAWKINS, R. D., HULSE, M. A., WILKINSON, C., HODSON, A. & GIBSON, M. (2001) The association football medical research programme: an audit of injuries in professional football. *British Medical Journal,* 35**,** 43-47.

HEITZ, N.A, EISENMANM P.A., BECK, C.L. & WALKER, J.A. (1999) Hormonal changes throughout the menstrual cycle and increased anterior cruciate ligament laxity in females. *Journal of athletic training,* 34**,** 144 - 149.

HERZOG, R. J., SILLIMAN, J. F., HUTTON, K., RODKEY, W. G. & STEADMAN, J. R. (1994) Measurements of the intercondylar notch by plain film radiography and magnetic resonance imaging. *American Journal of Sports Medicine,* 22**,** 204-210.

HOGAN, M. T. & STAHELI, L. T. (2002) Arch height and lower limb pain: an adult civilian study. *Foot Ankle Int,* 23**,** 43-47.

HOPPER, D. (1994) Foot types and lower limb injuries in elite netball players. *Journal of the American Podiatric Medical Association,* 84**,** 355-362.

HOUSEWORTH, S. W., MAURO, V. J., MELLON, B. A. & KIEFFER, D. A. (1987) The intercondylar notch in acute tears of the anterior cruciate ligament: a computer graphics study. *American Journal of Sports Medicine,* 15**,** 221-224.

JOHNSON, R. J. (1983) The anterior cruciate ligament problem. *Clin Orthop,* 172**,** 14-18.

KAUFMAN, K. R., BRODINE, S. K., SHAFFER, R. A., JOHNSON, C. W. & CULLISON, T. R. (1999) The Effect of Foot Structure and Range of Motion on Musculoskeletal Overuse Injuries. *American Journal of Sports Medicine,* 27**,** 585-593.

KIRKENDALL, D. T. & GARRETT JR, W. E. (2000) The anterior cruciate ligament enigma. Injury mechanisms and prevention. *Clinical Orthopaedics and Related Research,* 372**,** 64-68.

KROSSHAUG, T., ANDERSEN, T. E., OLSEN, O. E. O., MYKLEBUST, G. & BAHR, R. (2005) Research approaches to describe the mechanisms of injuries in sport: limitations and possibilities. *British Journal of Sports Medicine,* 39**,** 330-339.

LOMBARDO, S., SETHI, P. M. & STARKEY, C. (2005) Intercondylar Notch Stenosis Is Not a Risk Factor for Anterior Cruciate Ligament Tears in Professional Male Basketball Players: An 11-Year Prospective Study. *American Journal of Sports Medicine,* 33**,** 29-33.

LOUDON, J. K., JENKINS, W. & LOUDON, K. L. (1996) The relationship between static posture and ACL injury in female athletes. *J Orthop Sports Phys Ther,* 24**,** 91-97.

MATHIESON, I., UPTON, D. & PRIOR, T. D. (2004) Examining the Validity of Selected Measures of Foot TypeA Preliminary Study. *Journal of the American Podiatric Medical Association,* 94**,** 275-281.

MCCRORY, J. L., YOUNG, M.J. & BOULTON, A. J. M. (1997) Arch index as a predictor of arch height. *Foot*, 7, 79, Cited in MENZ, H. B. (1998) Alternative techniques for the clinical assessment of foot pronation. *Journal of the American Podiatric Medical Association,* 88**,** 119-128.

MCKENZIE, D. C., CLEMENT, D.B. & TAUNTON, J.E. (1985) Running shoes, orthotics and injuries. *Sports medicine,* 2**,** 334 - 347.

MENZ, H. B. (1998) Alternative techniques for the clinical assessment of foot pronation. *Journal of the American Podiatric Medical Association,* 88**,** 119-128.

MORE, R. C., KARRAS, B. T., NEIMAN, R., FRITSCHY, D., WOO, S. L. & DANIEL, D. M. (1993) Hamstrings--an anterior cruciate ligament protagonist. An in vitro study. *The American Journal of Sports Medicine,* 21**,** 231-237.

MOUL, J. L. (1998) Differences in selected predictors of anterior cruciate ligament tears between male and female NCAA Division I collegiate basketball players. *Journal of Athletic Training,* 33**,** 118-121.

MURPHY, D. F., CONNOLLY, D. A. J. & BEYNNON, B. D. (2003) Risk factors for lower extremity injury: a review of the literature. *British Journal of Sports Medicine,* 37**,** 13-29.

NIGG, B. M., COLE, G. K. & NACHBAUER, W. (1993) Effects of arch height of the foot on angular motion of the lower extremities in running. *J Biomech,* 26**,** 909-916.

ORCHARD, J. (2002) Is There a Relationship Between Ground and Climatic Conditions and Injuries in Football? *Sports Medicine,* 32**,** 419-432.

ORCHARD, J., SEWARD, H., MCGIVERN, J. & HOOD, S. (1999) Rainfall, evaporation and the risk of non-contact anterior cruciate ligament injury in the Australian Football League. *Med J Aust,* 170**,** 304-306.

ORCHARD, J. W., CHIVERS, I., ALDOUS, D., BENNELL, K. & SEWARD, H. (2005) Rye grass is associated with fewer non-contact anterior cruciate ligament injuries than bermuda grass. *British Journal of Sports Medicine,* 39**,** 704-709.

PALMER, I. (1938) Onn the injuries to the ligaments of the knee joint. A clinical study. *Acta Chir Scand*, 81, 1-282, Cited in ANGELO, R. C. O., MORAES, S. R. A., SURUAGY, L. C., TASHIRO, T. & COSTA, H. M. (2004) Morphometric study of the femoral intercondylar notch of knees with and without injuries of anterior cruciate ligament (ACL), by the use of software in digitalized radiographic images. *Acta Ortopdica Brasileira,* 12**,** 146-154.

PICCIANO, A. M., ROWLANDS, M.S. & WORRELL, T. (1993) Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. *J Orthop Sports Phys Ther*. 18, 553.

RAMIREZ, M., SCHAFFER, K. B., SHEN, H., KASHANI, S. & KRAUS, J. F. (2006) Injuries to High School Football Athletes in California. *The American Journal of Sports Medicine,* 34**,** 1147 -1157.

ROOT, M. L., ORIEN, W. P. &WEED, J. H. (1977) Normal and abnormal function of the foot, *Clinical Biomechanics Corp,* Cited in EVANS, A. M., COPPER, A. W., SCHARFBILLIG, R. W., SCUTTER, S. D. & WILLIAMS, M. T. (2003) Reliability of the Foot Posture Index and Traditional Measures of Foot Position. *Journal of the American Podiatric Medical Association,* 93**,** 203-213.

SIMKIN, A. & LEICHTER, I. (1990) Role of the calcaneal inclination in the energy storage capacity of the human foot—a biomechanical model. *Medical and Biological Engineering and Computing,* 28**,** 149-152.

SNELL, R. S. (2004) *Clinical Anatomy*. Philidelphia: Lippincott Williams & Wilkins. pp:678-685.

STAHELI, L. T. (1987) The longitudinal arch. A survey of eight hundred and eighty-two feet in normal children and adults. *The Journal of Bone and Joint Surgery,* 69**,** 426-428.

TRIMBLE, M. H., BISHOP, M. D., BUCKLEY, B. D., FIELDS, L. C. & ROZEA, G. D. (2002) The relationship between clinical measurements of lower extremity posture and tibial translation. *Clin Biomech (Bristol, Avon),* 17**,** 286-290.

TROJIAN, T. H. & COLLINS, S. (2006) The Anterior Cruciate Ligament Tear Rate Varies by Race in Professional Women's Basketball. *The American Journal of Sports Medicine,* 34**,** 895-898.

URRY, S. R. & WEARING, S. C. (2001) A Comparison of Footprint Indexes Calculated from Ink and Electronic Footprints. *Journal of the American Podiatric Medical Association,* 91**,** 203-209.

WEBB, J. (1998) Rugby football and anterior cruciate ligament injury. *British Journal of Sports Medicine,* 32**,** 2.

WEM, D. Y., PUFFER, J. C. & SCHMALZRIED, T. P. (1998) Injuries in runners: a prospective study of alignment. *Clinical Journal of Sports Medicine,* 8, 187-194

WILLIAMS III, D. S., MCCLAY, I. S. & HAMILL, J. (2001) Arch structure and injury patterns in runners. *Clin Biomech,* 16**,** 341-347.

WOJTYS, E. M., HUSTON, L. J., LINDENFELD, T. N., HEWETT, T. E. & GREENFIELD, M. (1998) Association Between the Menstrual Cycle and Anterior Cruciate Ligament Injuries in Female Athletes. *American Journal of Sports Medicine,* 26**,** 614-619.

Appendices

Appendix 1

Consent Form

For Participating in the Study of:
Is foot type an indicator of the type if injuries that might occur in sporting people.

(Details of project can be found in attached letter and information sheet)

Please tick the boxes

I have read the study information sheet and understand what is involved. ☐

I understand that the information I disclose will remain confidential and that my data will be destroyed or returned to me after being collated. ☐

I understand that I can withdraw my participation at any time. * ☐

I understand that the study will not directly result in increased service provision within the study topic area. ☐

I am willing to participate in this project. ☐

Signed: .... Date: ....

Appendix 2

Questionnaire

Thank you for taking the time to participate in this study. All the information collected during this study will be kept confidential and so please answer all questions as accurately as possible. If you are unsure about a question please do not hesitate to ask for advice.

Please be reassured that you are under no obligation to participate in this study and if at any time you wish to withdraw from the research, you have the right to do so.

Thank you once again for taking the time to help in this research project.

When filling in the questionnaire please delete where appropriate and for the questions that require a written answer, please enclose as much detail as you wish.

Personal Details

1. What is your height? …….ft…….inches
2. How much do you weigh? …….st………lbs
3. Date of Birth? ……./……/……

Information about the sport and your injury

4. At what level of football do you/did you play? Amateur / Semi-Professional / Professional.
5. How often do you/did you train each week?………………………………………..
6. Do you/did you always warm up before training and before a game? Yes/ No
7. Did you have your knee injury diagnosed by a doctor? Yes/No
8. How old were you when you injured your cruciate ligament?…………
9. Did the cruciate ligament injury occur when playing football? Yes/No
10. What type of boots were you wearing when you injured your cruciate ligament? Screw in Studs / Blades / Moulded Studs
11. Previous to your cruciate ligament injury, did you suffer from any other injury? If Yes, please give details: ……
12. Have you had a cruciate ligament injury to one or both knees? One / Both

    (If both please continue to question 14)
13. If you have only had a cruciate ligament injury to one knee, which knee suffered the injury? Left/ Right

14. Are you right or left footed? Right/ Left

15. Are you aware which cruciate ligament you injured? Yes/No

    (If yes, please continue to question 15. If No, you have now completed the questionnaire)

16. Which cruciate ligament did you injure? Anterior Cruciate Ligament / Posterior Cruciate Ligament

You have now reached the end of the questionnaire

Thank you for your participation, the information you have provided will be beneficial to the study and the time you have taken to fill in this study and take part in the research is much appreciated.

Appendix 3

THE UNIVERSITY OF NORTHAMPTON
School of Health

Questionnaire – Non-ACL

Thank you for taking the time to participate in this study. All the information collected during this study will be kept confidential and so please answer all questions as accurately as possible. If you are unsure about a question please do not hesitate to ask for advice.

Please be reassured that you are under no obligation to participate in this study and if at any time you wish to withdraw from the research, you have the right to do so.

Thank you once again for taking the time to help in this research project.

When filling in the questionnaire please delete where appropriate and for the questions that require a written answer, please enclose as much detail as you wish.

Personal Details

17. What is your height? …….ft…….inches
18. How much do you weigh? …….st………lbs
19. Date of Birth? ……./……/……

Information about the sport and your injury

20. At what level of football do you/did you play? Amateur / Semi-Professional / Professional.
21. How often do you/did you train each week?………………………………………..
22. Do you/did you always warm up before training and before a game? Yes/ No
23. What type of boots do you generally use for training? Screw in Studs / Blades / Moulded Studs
24. What type of boots do you generally use for playing? Screw in Studs / Blades / Moulded Studs
25. Have you ever suffered any sporting injury? If Yes, please give details:
……
……
……
……
26. Are you right or left footed? Right/ Left
27. How long have you played football for?………….. Years.

You have now reached the end of the questionnaire

Thank you for your participation, the information you have provided will be beneficial to the study and the time you have taken to fill in this study and take part in the research is much appreciated.

Appendix 4

Height Weight Table

Height	Acceptable Weight Range If aged 19-34	Acceptable Weight Range If aged 35+
5 feet 0"	97-128 pounds	108-138 pounds
5 feet 1"	101-132	111-143
5 feet 2"	104-137	115-148
5 feet 3"	107-141	119-152
5 feet 4"	111-146	122-157
5 feet 5"	114-150	126-162
5 feet 6"	118-155	130-167
5 feet 7"	121-160	134-172
5 feet 8"	125-164	138-178
5 feet 9"	129-169	142-183
5 feet 10"	132-174	146-188
5 feet 11"	136-179	151-194
6 feet 0"	140-184	155-199

Source: US Diet Guidelines

(Collins, A. 2005)

Appendix 5

Pronated foot type and Non-acl injury

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
ACL injury/No ACL injury? * Are they pronated?	50	100.0%	0	.0%	50	100.0%

ACL injury/No ACL injury? * Are they pronated? Crosstabulation

			Are they pronated?		Total
			yes	no	
ACL injury/No ACL injury?	ACL	Count	2	23	25
		Expected Count	8.5	16.5	25.0
		% within ACL injury/No ACL injury?	8.0%	92.0%	100.0%
		% within Are they pronated?	11.8%	69.7%	50.0%
		% of Total	4.0%	46.0%	50.0%
	Non-ACL	Count	15	10	25
		Expected Count	8.5	16.5	25.0
		% within ACL injury/No ACL injury?	60.0%	40.0%	100.0%
		% within Are they pronated?	88.2%	30.3%	50.0%
		% of Total	30.0%	20.0%	50.0%
Total		Count	17	33	50
		Expected Count	17.0	33.0	50.0
		% within ACL injury/No ACL injury?	34.0%	66.0%	100.0%
		% within Are they pronated?	100.0%	100.0%	100.0%
		% of Total	34.0%	66.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	15.062(b)	1	.000	.000	.000
Continuity Correction(a)	12.834	1	.000		
Likelihood Ratio	16.514	1	.000	.000	.000
Fisher's Exact Test				.000	.000
N of Valid Cases	50				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.50.

Directional Measures

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.	Exact Sig.
Nominal by Nominal	Lambda	Symmetric	.429	.158	2.224	.026	
		ACL injury/No ACL injury? Dependent	.520	.114	3.523	.000	
		Are they pronated? Dependent	.294	.247	1.010	.312	
	Goodman and Kruskal tau	ACL injury/No ACL injury? Dependent	.301	.116		.000(c)	.000
		Are they pronated? Dependent	.301	.119		.000(c)	.000

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.
c Based on chi-square approximation

Symmetric Measures

		Value	Approx. Sig.	Exact Sig.
Nominal by Nominal	Phi	-.549	.000	.000
	Cramer's V	.549	.000	.000
	Contingency Coefficient	.481	.000	.000
N of Valid Cases		50		

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Appendix 6

Neutral foot type and ACL injury

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
ACL injury/Non-ACL injury? * Is the foot in a neutral position?	50	100.0%	0	.0%	50	100.0%

ACL injury/Non-ACL injury? * Is the foot in a neutral position? Crosstabulation

			Is the foot in a neutral position?		Total
			YES	NO	
ACL injury/Non-ACL injury?	ACL	Count	5	20	25
		Expected Count	6.0	19.0	25.0
		% within ACL injury/Non-ACL injury?	20.0%	80.0%	100.0%
		% within Is the foot in a neutral position?	41.7%	52.6%	50.0%
		% of Total	10.0%	40.0%	50.0%
	NACL	Count	7	18	25
		Expected Count	6.0	19.0	25.0
		% within ACL injury/Non-ACL injury?	28.0%	72.0%	100.0%
		% within Is the foot in a neutral position?	58.3%	47.4%	50.0%
		% of Total	14.0%	36.0%	50.0%
Total		Count	12	38	50
		Expected Count	12.0	38.0	50.0
		% within ACL injury/Non-ACL injury?	24.0%	76.0%	100.0%
		% within Is the foot in a neutral position?	100.0%	100.0%	100.0%
		% of Total	24.0%	76.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.439(b)	1	.508	.742	.371
Continuity Correction(a)	.110	1	.741		
Likelihood Ratio	.440	1	.507	.742	.371
Fisher's Exact Test				.742	.371
N of Valid Cases	50				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.00.

Directional Measures

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.	Exact Sig.
Nominal by Nominal	Lambda	Symmetric	.054	.090	.579	.562	
		ACL injury/Non-ACL injury? Dependent	.080	.133	.579	.562	
		Is the foot in a neutral position? Dependent	.000	.000	.(c)	.(c)	
	Goodman and Kruskal tau	ACL injury/Non-ACL injury? Dependent	.009	.026		.512(d)	.742
		Is the foot in a neutral position? Dependent	.009	.026		.512(d)	.742

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.
c Cannot be computed because the asymptotic standard error equals zero.
d Based on chi-square approximation

Symmetric Measures

		Value	Approx. Sig.	Exact Sig.
Nominal by Nominal	Phi	-.094	.508	.742
	Cramer's V	.094	.508	.742
	Contingency Coefficient	.093	.508	.742
N of Valid Cases		50		

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Appendix 7

Supinated foot type and ACL injury

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
ACL injury/No ACL injury? * Are they supinated?	50	100.0%	0	.0%	50	100.0%

ACL injury/No ACL injury? * Are they supinated? Crosstabulation

			Are they supinated?		Total
			yes	no	
ACL injury/No ACL injury?	ACL	Count	18	7	25
		Expected Count	10.5	14.5	25.0
		% within ACL injury/No ACL injury?	72.0%	28.0%	100.0%
		% within Are they supinated?	85.7%	24.1%	50.0%
		% of Total	36.0%	14.0%	50.0%
	N-ACL	Count	3	22	25
		Expected Count	10.5	14.5	25.0
		% within ACL injury/No ACL injury?	12.0%	88.0%	100.0%
		% within Are they supinated?	14.3%	75.9%	50.0%
		% of Total	6.0%	44.0%	50.0%
Total		Count	21	29	50
		Expected Count	21.0	29.0	50.0
		% within ACL injury/No ACL injury?	42.0%	58.0%	100.0%
		% within Are they supinated?	100.0%	100.0%	100.0%
		% of Total	42.0%	58.0%	100.0%

Directional Measures

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.	Exact Sig.
Nominal by Nominal	Lambda	Symmetric	.565	.136	3.523	.000	
		ACL injury/No ACL injury? Dependent	.600	.136	3.030	.002	
		Are they supinated? Dependent	.524	.164	2.315	.021	
	Goodman and Kruskal tau	ACL injury/No ACL injury? Dependent	.369	.132		.000(c)	.000
		Are they supinated? Dependent	.369	.133		.000(c)	.000

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.
c Based on chi-square approximation

Symmetric Measures

		Value	Approx. Sig.	Exact Sig.
Nominal by Nominal	Phi	.608	.000	.000
	Cramer's V	.608	.000	.000
	Contingency Coefficient	.519	.000	.000
N of Valid Cases		50		

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.