MONASH UNIVERSITY

ACCIDENT RESEARCH CENTRE

# HEADING INJURIES OUT OF SOCCER: A REVIEW OF THE LITERATURE


by

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Heading injuries out of soccer: A review of the literature


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**Abstract:**

Soccer is the most popular sport in the world, and one of the most popular in Australia. Soccer is characterised as vigorous, high intensity, intermittent, ball and contact sport. The characteristics of soccer along with the required functional activities obviously places great demands on the technical and physical skills of individual players. A direct blow from a soccer ball or a stray kick may result in fractures, bruising, or even death. Soccer players can also suffer from a range of overuse injuries associated with running, jumping, pivoting, heading and kicking of the ball. The overall aim of this report is to critically review both the formal literature and informal sources that describe injury prevention measures, or countermeasures, for soccer. The range of countermeasures for preventing soccer injuries is presented in this report, together with an assessment of the extent to which they have been formally demonstrated to be effective. Such countermeasures include pre-season conditioning, protective equipment including shin guards, warm-up programs, attention to environmental conditions, adequate footwear, modified rules, education and coaching, first aid and rehabilitation. Recommendations include the need to conduct more biomechanical and epidemiological research into the mechanisms of injury; further development and testing of protective equipment; improving education for both players and coaches, particularly at the wider community level; adopting modified rules for children; extending pre-participation screening to the general soccer community; providing prompt first aid; and improved injury data collections, particularly for the less formal level of play.



**Key Words:**
soccer, injury prevention, collisions,
overuse, evaluation, countermeasures.





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# EXECUTIVE SUMMARY

Soccer is characterised as vigorous, high intensity, intermittent, ball and contact sport. Functional activities include acceleration, deceleration, jumping, cutting, pivoting, turning, heading and kicking of the ball (Inklaar, 1994a). It is obvious that the game of soccer puts many demands on the technical and physical skills of the individual player (Inklaar, 1994a). Soccer is one of the most popular sports with over 270,000 registered Australian players and approximately 200 million players in 186 countries registered with the International Federation of Football Association (FIFA, 1992). Further there is estimated to be a equal number of unlicensed soccer players (Inklaar, 1994a).

With an increase in popularity and expectation of players, along with the characteristics of soccer, significant numbers of injuries are conceivable. Although a significant amount has been published on the epidemiology and biomechanics of soccer injuries, there are few formal, controlled evaluations of the effectiveness of injury prevention countermeasures.

This report aims to critically review both formal literature and informal sources that describe injury prevention measures (countermeasures). It provides an evaluation of the extent to which these countermeasures have been demonstrated to be effective. Unlike other literature describing soccer injuries, this report does not specifically focus on the epidemiology of soccer injuries, nor their aetiology. Instead, it presents a detailed examination of the range of countermeasures promoted to prevent soccer injuries. A brief overview of the epidemiology of soccer injuries, particularly from an Australian perspective, is given to set the scene for the subsequent discussion of countermeasures.

Recommendations for further research, development and implementation are based on the review presented here and discussions with experts acknowledged in this report. Many of the recommended countermeasures have not yet been proven to be effective and further controlled evaluation studies are needed. A summary of the countermeasures reviewed and recommendations for further research, development and implementation are given below.

## LOWER LEG INJURIES AND TECHNIQUE

The nature of the game of soccer, in which players make sharp turns off a planted foot, and intense contact with the ball and other players, along with the essential underlying components of running and kicking, indicate the vulnerability of the lower extremities. The epidemiological soccer literature clearly indicates that the majority of soccer injuries occur to the lower extremities. Lower extremity injuries account for between 58% to 93% of all injuries for adults and 39.1% to 89% for children. The dominant injuries occur to the knees, ankles and shins. Countermeasures include correct footwear and shin guards.

### Recommendations

- Studies are required on the causes and prevention of lower leg injuries. Research questions still to be answered included:
  - Which features of footwear are protective against soccer injuries?
  - Where should the balance lie between foot protection and stabilising effects of footwear and flexibility of shoes etc.?
  - What is the interaction between footwear and specific playing surfaces?
  - Do cushioning effects of footwear mask longer term damaging effects?
- Research studies need to take into account measures of exposure such as hours played, hours of training, position on the field etc.
- Evidence on the effects of interventions between footwear and surfaces should be reviewed with reference to other sports.

- Where the effectiveness of countermeasures have been proven and regulated eg. shin guards, enforcement at all levels of the game during practice and competition should occur.
- Shin guards and footwear should be further and continually developed.
- Equipment such as shin guards and footwear should be fitted with professional advice.
- The use of wobble board training should be encouraged.

## HEAD INJURIES

While the vast majority of soccer injuries occur to the lower extremities, injuries to the head and neck may also occur. From the international literature, the proportion of total injuries to the head, spine and trunk areas ranges from 4-22% in adults and 9-26% in youths. Head injuries are sustained from heading the ball, ball strikes to the head and head to head contact, most often when two players attempt to head the ball simultaneously. Common head injuries include lacerations and concussion. Unlike injuries to the lower extremities, injuries to the head and neck have greater potential to be catastrophic.

### Recommendations

- Use only plastic coated balls
- Once water resistance qualities are lost, replace the ball.
- Use the appropriate sized ball for the age and gender group playing.
- Teach the player to head correctly and to maintain eye contact with the ball before and after contact is made (Dods, undated).
- Ensure the head and neck are kept rigid at impact and, once this basic technique has been acquired, only then progress to the standing jump and finally to the running jump (Dods, undated).
- The development of strong neck musculature, to keep the neck rigid at impact (Dods, undated).
- Strengthen the hip flexor and abdominal muscles for the ballistic action in the standing header.
- Children should be specifically trained and monitored in terms of correct heading technique
- Investigations should be made into the advantages and disadvantages of a lightweight helmet for soccer.
- Epidemiological research into the incidence of head injuries and associated factors should be undertaken
- Current evidence is not conclusive, thus further controlled studies of heading need to be conducted.
- The recommendations made by NHMRC should be endorsed.

## FACIAL INJURIES

Most sports can give rise to dental, mouth and face damage, though contact sports such as soccer, have been shown to have a relatively higher incidence. There is an absence of FIFA rules for protection from orofacial injury and no mention of such devices in texts for coaches and athletes.

### Recommendations

- Investigate the advantages and disadvantages of developing a light weight soccer helmet.

- Epidemiological research into the incidence and circumstances of eye, dental and face injuries should be undertaken based on participation rates.
- Barriers to the use of mouthguards should be determined.
- Mouthguards should be used by all players.

## GOAL POSTS

Over a 16 year period (1979-1994), the Consumer Product Safety Commission, a United States federal government agency, reported at least 21 deaths and an estimated 120 injuries involving falling soccer goal posts had been treated in US hospital emergency rooms. These statistics do not encompass the numerous injuries that occur and do not receive emergency treatment.

### Recommendations

- Ensure both portable and permanent goals are securely anchored to the ground.
- Ensure portable goals are made of a lightweight material.
- Dismantle, remove, tie up or secure to a permanent structure portable goals after use.
- Cover goals with protective padding.
- Conduct further research into goal post design.
- Conduct epidemiological studies looking at the mechanism and types of injuries associated with goal posts.

## RULES OF THE GAME

Pushing, holding, barging, tripping, striking or intentional kicking are not allowed in soccer and free-kicks are awarded when rules are broken. If a player commits a serious foul, abuses an official or continues to break the rules, then they can be warned with a yellow card, or sent from the field with the presentation of a red card.

### Recommendations

- Players need to be educated that foul play is not an acceptable part of the game.
- The deterrent effect of the send off rule with limited substitution, should be examined in comparison with the benefits of encouraging injured players to leave the field with unlimited substitution.
- Rules need to be enforced.

## CROWD CONTROL

A major concern to the reputation and popularity of soccer is the worldwide risk of injury and even death through crowd violence. Although Australia has been less prone to this than other countries, signs of tensions in supporting crowds have begun to emerge in recent years.

### Recommendations

- Ensure that the FIFA regulations are fully enforced

## PHYSICAL PREPARATION

A soccer player needs to meet at least minimum physical, physiological and psychological requirements to cope with the demands of competition and reduce the risk of injury. Individual player factors are often related to soccer injuries and can be prevented through corrections in training and conditioning. Warm-up and stretching is also recommended to increase playing ability, however, its role in injury prevention is controversial.

## Recommendations

- More research into the role of warm-up, training and conditioning as an injury prevention measure for soccer is needed.
- Controlled research studies should be undertaken into the benefits of different types of warming-up, cooling-down and stretching practices.
- Information about warm-up, cool-down and stretching techniques should be developed and widely promoted to improve specific knowledge of techniques and effectiveness.
- Simple fitness testing should be conducted prior to soccer competition to ensure adequate fitness levels for competition.
- Appropriate education and monitoring of players should be conducted regarding nutritional and hydration demands of soccer, particularly as intensity increases with a training programme, and emphasising complex carbohydrate intake
- Recreational soccer players should not train excessively. If fitness is the overall goal, soccer drills could be interspersed with other activities.
- Soccer players should consider some form of cross-training (eg. bicycling) to improve their fitness levels and remain injury free.
- Soccer skills and fitness should be built-up gradually.
- Soccer players with potential biomechanical abnormalities (eg. leg length discrepancies) should have these assessed by a professional who can recommend corrective actions.
- More research is needed to determine the threshold and optimal levels of the various training factors under which soccer players are likely to remain injury free.
- A campaign aimed at increasing soccer players' awareness of the injury consequences of training errors should be developed and promoted.

## PREVENTING OVERUSE INJURIES

Soccer players, like any athletes today, are expected to train harder and longer, and to commence at an earlier age, if they are to succeed at the elite level. It is, therefore, not surprising that there is an increasing number of overuse injuries. An overuse injury results from an accumulation of stresses to the involved tissue - bone, ligaments or tendons. Alternatively, an overuse injury could result from a previous injury for which the body compensates, by increasing the stress on another part of the body, eventually leading to tissue breakdown and overt injury at the vulnerable site.

## Recommendations

- More research into the aetiology of overuse injuries needs to be undertaken.
- Soccer players should be educated about the risk and severity of overuse injuries.
- Soccer players with potential biomechanical error (eg. leg length discrepancies) should have these assessed by a professional who can recommend corrective actions.
- Coaches and trainers should be educated in the importance of gradual increases in training, particularly pre-season or in the early part of the season.

## ENVIRONMENTAL CONDITION

Traditionally soccer is played on a rectangular field, predominantly a grass surface, and less commonly a surface of sand, gravel or artificial turf. During a game a player covers a large percentage of this area and suffers significant impact forces of two to three times body weight. For this reason the surface and the environmental surrounds are important factors to consider when reviewing the nature and incidence of soccer injuries.

## Recommendations

- Risk management plans to control environmental hazards should be developed, implemented and monitored for facilities.
- More research into the role of environmental conditions such as playing surface and weather conditions should be undertaken in a controlled manner.
- Soccer should not be played under extremes of weather conditions.
- Adequate player hydration should be ensured.
- Soccer players should use a broad spectrum sunscreen in high ultra-violet conditions
- A wet globe bulb temperature system should be available at all soccer matches which are played under hot and humid conditions to assess heat load.
- Risk management plans should incorporate specific regulations regarding the environment.
- Further research needs to be conducted on the interaction between footwear and specific playing surfaces.
- Evidence on the effects of interventions between footwear and surfaces should be reviewed with reference to other sports.

## MODIFIED RULES AND CHILDREN

Significant differences exist between child and adult athletes. Therefore injury prevention strategies for children should be considered separately to those for adults, despite the fact that their injuries may be attributed to many of the factors associated with adult soccer players.

## Recommendations

- The modified rules version of soccer (Rooball) should be widely implemented
- Children should be encouraged to play with smaller sized balls as in Rooball at all times
- Children and adolescents should be taught correct techniques and procedures.
- The use of shin guards should be enforced.

## EDUCATION AND COACHING

Education, as a component of injury prevention should cover a wide range of aspects such as facilities, training and treatment. Guidelines have been produced by the Australian Sports Commission and the Australian Soccer Federation to aid in school education programs, particularly on Rooball and progression to traditional soccer.

## Recommendations

- All coaches should be accredited and undergo regular re-accreditation.
- Coach education schemes should be updated regularly to ensure they provide current information.
- Instruction clinics for the wider community should be developed and made widely available.
- Education resources for informal soccer need to be developed and disseminated.
- Schools should seek advice from the Aussie Sports Program in terms of modified rules, as well as the state organisation for guidance on program development.

## FIRST AID AND REHABILITATION

Injuries need to be properly managed to restrict the possibility of further damage. Overall, the treatment goals are pain relief, promotion of healing, decreased inflammation, and a return to functional and sports activities as soon as possible. This procedure may involve, first aid, taping or bracing, referral and general rehabilitation.

## Recommendations

- Controlled research is needed to determine the effectiveness of taping and bracing of ankle and knee joints in the primary presentation of injury
- Taping or bracing should be considered by professionals in the prevention of re-injury of ankle joints
- Return to play after injury should only occur after full recovery
- Qualified first aid personnel should be available at all sporting events.
- Conduct research into the biomechanics of acceleration, deceleration, jumping, cutting, pivoting, turning, heading and kicking of the ball.
- Ensure that all players have prompt and adequate first aid treatment.
- Further players should undergo controlled rehabilitation before returning to play after an injury.

## INDOOR SOCCER/FUTSAL

Indoor soccer, is played by over 100 countries with 12 million players world wide. Futsal is the only official form of indoor soccer approved under the auspices of the FIFA. While the strategy is the same in both indoor and outdoor soccer, the confined indoor area demands quick reflexes, fast thinking, and pin-point passing and leads to an increase in injuries. Indoor soccer injuries are generally similar to those of the outdoor game.

## Recommendations

- Well designed studies are required to determine the relative risk of injury between indoor and outdoor soccer.
- Epidemiological studies in terms of the mechanism of injury and the relation to the games surrounds needs to be conducted.
- Risk management plans should be prepared, implemented and monitored based on the apparent risk of futsal.

## GENERAL SUMMARY AND CONCLUSIONS

This report has discussed hospital emergency department data, epidemiological data presented in the literature and the full range of injury prevention activities for preventing soccer injuries. The proportion of emergency department presentations reported for both child and adult injury in Victoria was generally within the ranges found in the literature in terms of body region and nature of injury. In addition to specific recommendations, the following more general recommendations have been made:

- Improved data collection about the occurrence of soccer injuries and their associated factors needs to be developed and maintained.
- Data about injuries and their associated factors in recreational soccer needs to be collected.
- Data collections should conform to guidelines for sports injury surveillance being developed and promoted nationally.
- Information about preventing soccer injuries should be disseminated widely through soccer broadcasts, soccer equipment points of sale, soccer and general magazines.

- Guidelines for minimum safety requirements for soccer events (including the need for mobile phones, telephone contacts, first aid kits, etc) should be developed and widely disseminated.
- Future research studies to determine risk factors and to evaluate the effectiveness of countermeasures need to be controlled.
- Risk management plans for sporting bodies, clubs and associations should be developed, implemented, enforced and regularly reviewed.

Risk management plans for facilities should be developed and implemented.

# 1. INTRODUCTION

Soccer is characterised as vigorous, high intensity, intermittent, ball and contact sport. Functional activities include acceleration, deceleration, jumping, cutting, pivoting, turning, heading and kicking of the ball (Inklaar, 1994a). It is obvious that the game of soccer puts many demands on the technical and physical skills of the individual player (Inklaar, 1994a).

Soccer, as played today, could be considered the final offshoot and the purest modern form of man's primitive kicking games (Brasch, 1971). Soccer has had an obscure establishment, from stories depicting decapitated heads of Norman enemies being kicked through the streets as a victory celebration, to King Edward III trying, unsuccessfully, to ban the game in 1314 as it was considered dangerous. Soccer has continued to thrive from its primitive beginning with various rules being established across England. It was not until all these variations on the theme came together at Cambridge University in 1863, that the "football association" and a generally accepted code were established. This was the commencement of modern football and its unified code. It should be noted that Australia is one of only a few countries that calls the game soccer, Europe and many other countries refer to it as 'football' or 'association football'. In Australia, soccer dates back to the 1880s. However soccer struggled for widespread recognition. It was not until the arrival of Europeans after World War II, that it underwent a major boom in participation rates. There are three major variations of recreational soccer played in Australia: the traditional outdoor game; indoor soccer (futsal) and; the modified junior game of rooball.

The most prestigious event in soccer today is the World Cup, which is held once every four years. Teams from all over the world battle through a series of qualifying rounds for one of only 32 berths, and it rivals the Olympics as the most watched event on the planet (Holmes, 1996).

With an increase in popularity and expectation of players, along with the characteristics of soccer, vast numbers of injuries are conceivable. A significant amount has been published on the epidemiology and biomechanics of soccer injuries. This has often included informed and expert conclusions on the causes of specific soccer injuries and how to prevent them. There is, however, a notable lack of formal, controlled evaluations of the effectiveness of injury prevention countermeasures in soccer.

# 2. AIMS

The aim of this report is to critically review both formal literature and informal sources that describe injury prevention measures, or countermeasures, for soccer. In doing so, the report provides an evaluation of the extent to which these countermeasures have been demonstrated to be effective.

Unlike other literature describing soccer injuries, this report does not specifically focus on the epidemiology of soccer injuries, nor does it provide a detailed description of their aetiology. Instead, it presents a detailed examination of the range of countermeasures promoted to prevent soccer injuries. A brief overview of the epidemiology of soccer injuries, particularly from an Australian perspective, is given to set the scene for the subsequent discussion of countermeasures.

# 3. METHOD

The sources of information used to compile this report were:

- Medline CD-ROM for published medical literature (over the past 10 years)
- Sport discus CD-ROM search for published sports literature (over the past 10 years)
- injury conference proceedings scans
- discussions with key Australian soccer injury researchers
- discussions with relevant soccer organisations
- scanning of Internet and world wide web sites.
- search of the informal literature database held by the Consumer Safety Institute Amsterdam

This review is based on English-language material only. It is acknowledged, however, that some of the European soccer injury information is published in other languages and that these articles have relevance to this report. Non-English language articles with English abstracts have been included in this review where appropriate.

The literature gathered generally covers the period from 1985 to 1997. Because the work of Ekstrand (1982) was very detailed and relevant work, this has also been included in this review.

The literature gathered for this review was critically assessed to determine the extent to which the various countermeasures have been fully evaluated and demonstrated to be effective in preventing injuries. A graduated scale for the strength of the evidence presented in the identified literature was developed by Kelsall and Finch (1996) and is applicable to the soccer context. This is shown in Figure 1.

***Figure 1: Grading scale for assessing the extent to which countermeasures have been fully evaluated***

| STRENGTH OF THE SCIENTIFIC EVIDENCE | TYPE OF SCIENTIFIC EVIDENCE |
|---|---|
| least ↑ | anecdotal or informed/expert opinion |
| | laboratory-based/equipment testing |
| | data-based evidence (uncontrolled) |
| ↓ **most** | controlled evaluations |

This scale reflects an epidemiological and rigorous scientific approach to injury prevention that considers demonstration of the effectiveness of a countermeasure's performance in the field to be the highest level of 'proof'. This is particularly important for sports injury countermeasures where any change to the nature of the game is an important factor to be considered. In general, changes to factors such as how the sport is played or undertaken, the behaviour of the participants and the level of enjoyment can only be measured during "in-the-field" evaluations.

At the lowest level of proof (ie the “least” evidence end of the scale) are anecdotal reports of injuries and their prevention and comments based on informed or expert opinion. This category would include, for example, statements like “I treated 5 cases of head and neck injuries during last year and all would have been prevented if they had used an adequate heading technique,” or “none of the children with shin injuries I treated last year were wearing shin guards”. Of course, some expert/informed opinion carries more weight than others, particularly when it is based on a critical review of available information.

Laboratory-based evidence is a very important source of information about sports injury countermeasures. This category includes reports that have explored equipment design and testing, development of standard testing procedures and biomechanical research, including that performed on animals, cadavers and simulated body tissue such as crash-test dummies. Such information provides detail about the extent to which countermeasures such as padding perform under certain stress and/or impact conditions. This research is generally performed under laboratory conditions which are often controlled. However, such conditions may not be a good representation of actual field or playing conditions.

Data-based evidence can take a number of forms. Routine injury surveillance systems document the incidence of new injury cases over periods of time. Patterns in data can be examined over time to draw conclusions about the impact that countermeasures may have had on injury rates. Cross-sectional epidemiological studies provide some information about injury prevalence at a given point of time but are unable to assess the influence of countermeasures on injury rates. Quasi-experimental studies enable a comparison of pre-intervention with post-intervention data to examine the effects of countermeasures.

Controlled evaluations provide the most definitive evidence for the impact of countermeasures. Case-control studies and longitudinal (cohort) studies are common forms of controlled studies. Neither study type allows random assignment of people (or injuries) to test and control groups, though they are examples of natural experiments. A randomised controlled trial is considered to provide the best evidence. In such studies, the units of interest (eg soccer playing position, shin guards, etc) are randomly assigned to test and control groups.

Another important aspect of countermeasure implementation is the extent to which they are accepted or adopted by the users for whom they were intended. Countermeasures should be acceptable to those they were designed to protect. Community consultation and awareness programs must therefore be considered in any implementation process. It is also important to assess barriers towards use of injury countermeasures. An examination of attitudes, knowledge and behaviours is crucial to this. Studies of these factors are generally conducted after implementation of a countermeasure and can highlight the need for behavioural or educational change at either the individual or organisational level. Because of the importance of this sort of research, the literature describing these studies is also included in this review.

Another measure of the success of countermeasures is a demonstration of their cost/benefit ratios. This information is often needed by regulatory bodies and those involved in policy or rule making, to inform their decisions about countermeasures. To date, there have been no studies of the economic benefits of soccer injury countermeasures.

# 4. PARTICIPATION IN SOCCER

Soccer is currently one of the worlds most popular sports. The International Federation of Football Association (FIFA) involves 186 countries with approximately 200 million registered players (FIFA, 1992). It is estimated that there is also an equal numbers of unlicensed soccer players (Inklaar, 1994a). Soccer Australia, currently reports that there are approximately 270,000 registered players in Australia.

Within Australia, it has been estimated that 4-7% of Australians over the age of 16, participated in soccer between 1987 and 1991 (Brian Sweeney and Associates, 1991). These surveys have also concluded that 82% of soccer players are male and 18% are female. Furthermore the majority of participants were aged 16-29 (62%). A limitation of these population estimates is that they were based on small sample sizes.

A larger population household survey conducted by the Australian Bureau of Statistics (ABS) in 1993/1994, indicated that 169,436 Australians over the age of 15 years participated in soccer. This number increased to 195,000 in 1994/95 and 198,000 in 1995/96. Specifically 162,700 people (88% male and 12% female) participated in outdoor soccer in 1995/1996. While a further 35,300 players (77% male and 23% female) were involved in indoor soccer. The majority of both indoor and outdoor soccer players were 15-24 years (71% and 59%, respectively). Indoor soccer players predominantly competed once a week (75%), while outdoor soccer players were more inclined to have competed more than once a week (54%). In Victorian, there were 27,400 players.

Although under 15 year olds are likely to make up a large proportion of all those participating in soccer, neither of these data sources collected information about people aged under 15 years.

Knox et al. (1997) conducted a survey of adolescent sports participants and injuries in NSW. They found soccer to be the second most popular sporting activity, with 24% of all those surveyed being a participant in the game. Soccer was second only to basketball which recorded a 30% participation rate of those surveyed.

## 4.1 Recommendation for participation data collection

- Participation data should also be collected for 15 year olds and below
- The format for collecting participation data should be consistent

# 5. AN OVERVIEW OF THE EPIDEMIOLOGY OF SOCCER INJURIES

To prevent injuries occurring in soccer, it is necessary to first analyse the incidence, type and localisation of injuries as well as the mechanisms behind the injuries (Ekstrand, 1994).

Limited Australian data exists on the incidence and types of soccer injuries within various population groups. Internationally, however, there is considerable epidemiological literature on the incidence and nature of soccer injuries (see Aglietti et al., 1994; Inklaar, 1994; Larson et al., 1996). Assessing the level of agreement between these studies is difficult, given the presentation of data in various forms along with differences in the study populations (ie. age, gender, sample size, participation time, level of play, socio-cultural background), data collection methods and injury definitions.

## 5.1 General Overview

### 5.1.1 Rate of injury

The Harstad injury prevention study, in Norway, found that soccer contributes to 44.8% of all sports injuries sustained, implying it has the highest population based incidence of injury compared to other sports (Ytterstad, 1996). Similar findings have been reported in review articles (see Aglietti et al., 1994; Inklaar, 1994; Larson et al., 1996). These studies, however, base their findings on incidence of injuries in the total population, rather than taking into consideration the number of injuries in relation to the number of participants.

The Consumer Product Safety Commission has determined through the National Electronic Injury Surveillance System (NEISS) that 647,368 injuries occurred from 1989 to 1992 associated with soccer (United States Consumer Product Safety Commission, 1992).

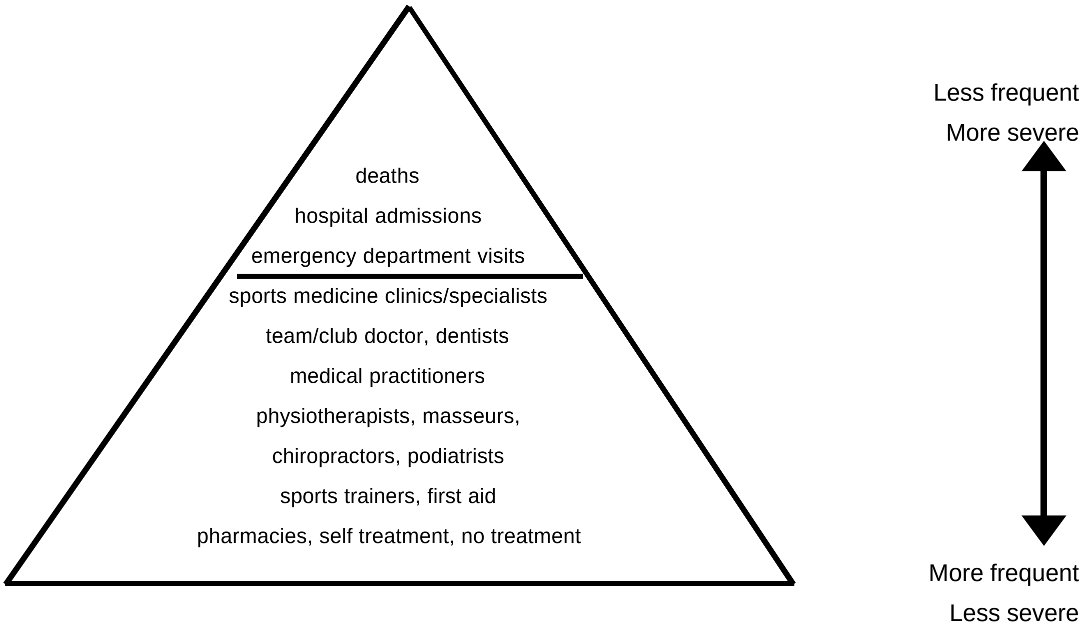
From an Australian perspective, Cunningham and Cunningham (1996), investigated the incidence of injury at the 1994 Australian University Games. Soccer was reported to have a 22.9% injury rate in relation to the total number of participants registered in soccer competitions throughout the games. This ranked soccer injuries as the eighth highest cause of sport related injury. Sprains accounted for 24% of these injuries, followed closely by bruising (23%), muscle-tendon injuries (16%) and abrasions (15%). It is important to note that the distribution of high frequency sports injuries will vary between countries according to the difference in popularity and injury incidence of the sport.

An analysis of Australian emergency room presentation data found that soccer injuries amongst adults (>15 years) accounted for 8% of all emergency departments sporting injury cases (Finch et al., 1995). This ranked soccer as the third greatest source of sports-related emergency department presentations. At the time of injury, 98% of injured cases were involved in soccer as a formal sporting activity (organised competition or practice: 84%; informal soccer: 5%; unspecified: 8%). The remaining 3% of soccer injuries presenting to emergency departments occurred during recreational soccer activities. This study also provided information about the body regions injured whilst participating in soccer. The lower extremity was the most commonly injured body region (60%), followed by upper extremities (23%) and head injuries (12%). The injuries recorded were predominantly sprains/strains (37%), fractures (21%) and bruising (15%).

Among children, soccer injuries contributed 6% of all sports-related emergency department injury presentations, ranking it as the fifth most common source of sports-related injuries in children (Finch et al., 1995). Amongst this group formal sporting activities contributed 91% of all soccer injuries (organised competition or practice: 59%; informal sport: 17%; unspecified: 14%). Recreational soccer accounted for 9% of all injuries. Upper extremity injuries were the most common injury (43%), followed by lower extremity injuries (39%) and head injuries (13%).

The range of possible settings for sports injury treatment, limits this study's representativeness of sports injury data collections as it is based on just one source of data from a particular place of treatment (Finch et al., 1995). As is shown in Figure 2, emergency department presentations represent injuries at the less frequent, more severe end of the scale. It is likely that the majority of soccer injuries, particularly overuse ones, would seek treatment from sources towards the "more frequent, less severe" end of the pyramid. Unfortunately, there is less data available for these sources of treatment.

***Figure 2: A sports injury pyramid***

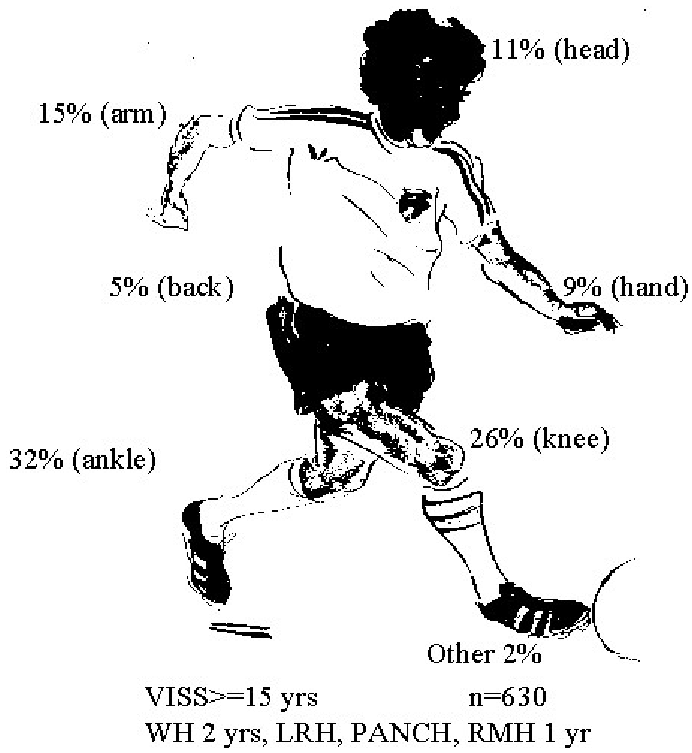



Source: Finch et al., 1995 (modified)

Similar findings, with the same limitations, were reported by Routley & Valuri (1993). In this report of adult soccer injuries in Victoria, it was found that people injured in soccer contributed 15% of all sporting injuries presenting to hospital emergency departments and 8% of all sports-related admissions following emergency department presentations. Males were the predominant group injured representing 96% of cases and people aged 15-19 years represented 42% of cases. Over-exerting/over-reaching led to 56% of injuries, while falls (20%) and collisions (11%) also accounted for a large number of the soccer related emergency department presentations. Injury resulted from the player hitting an object in 35% of cases, while 30% of injuries resulted from a hit by an object. Strain/over-exertion accounted for 27% of injuries while collision type injuries attributed to only 7% of all injuries. The most frequently injured body region was the lower extremity, often as a result of player contact, eg being kicked or collisions. Injuries to the ankle accounted for 22% of all injuries, followed by the knee (13%), lower leg (10%) and foot (10%).

Figure 3 shows the most commonly injured body regions amongst adult soccer-related emergency department presentations recorded by VISS.

***Figure 3: Adult soccer injuries by body part recorded by the Victorian Injury Surveillance System.***




*Illustrated by: Ann Jones.*
*Reproduced from Hazard, 15, 1993,*

The Victorian Injury Surveillance System (1991) also reported that soccer was responsible for 21% of sporting injuries sustained by children (Routley, 1991). Of these, 93% of cases were male. Eighty percent of child cases were aged 10-14. The wrist/forearm (22% of all cases), ankle (13%) and feet (10%) were the most common body parts injured. Nearly one third of all soccer injuries to children where as a result of falls.

An updated description of hospital emergency department presentations data for soccer related injuries in Victoria is given in Section 5.2.

### 5.1.2 Injury type

In a review of the epidemiological literature the most common adult injuries in soccer were sprains accounting for between 18 and 49%. Other common types of injury include strains (10-30%), contusions (2-25%) and wounds (4-32%). Specifically in youths contusions (32-47%) were found to be the most common injuries followed by sprains (19-35%), strains (10%-28%). For a overview of reported adult injury type see appendix 1; and appendix 2 for reported youth injury type.

### 5.1.3 Injury severity

Injury severity can be classified in a number of ways: nature of injury; duration and nature of treatment; sporting time lost; work time lost; permanent damage and cost (van Mechelen et al., 1992; Finch et al, 1995). Larson et al. (1996) in review, reported that 27-74% of injuries required less that one weeks absence from activity, while 19-36% required 1 week to 1 month and 11-35% required over 1 month. In terms of emergency department presentations, 8% of adult and 7% of child soccer injuries were admitted to hospital (Routley, 1991; Routley & Valuri, 1993).

### 5.1.4 Injury location

The location of soccer injuries has been reported to be predominantly associated with the lower extremities (75.4%-93%) (Albert, 1983; Ekstrand & Gillquist, 1983; Engström et al., 1991; Larson et al., 1996). Data collection by the National Collegiate Athletic Association (NCAA) over a ten year period has also reported that injuries are typically associated with the lower extremities (National Collegiate Athletic Association, 1994-1995). The predominance of injuries to the lower extremity is not surprising given the nature of the sport. A comparison of the reported incidence rates for body location and injury type can be found in appendix 3 and 4. The review in these appendices support reports that the most common soccer injuries occur in the lower extremities with adults recording 59-93% and youths 22-69% lower extremity injuries. Upper extremity injuries were also frequently reported (4-43%) in youths.

### 5.1.5 Position of play

When establishing the incidence of injury according to player position, the unequal and often variable number of players in position must be taken into account. In a review of the literature Larson et al. (1996) reported conflicting results. Two studies (Keller, 1987; Sandelin, 1985) reported no significant differences between injury rates of players at different position. In contrast, Engström (1991) found the highest percentage of injuries occurred to backs and mid-fielders (36% each) compared to forwards and goal keepers who sustained 18% and 9% of injuries, respectively. Other studies have also reported differing injury rates with regard to position of play (Aglietti et al., 1994)

### 5.1.6 Competition versus practice

A comparison of risk of injury in competition and practice games has been made in a number of studies (Backx et al., 1991; Nielsen & Yde, 1989; Ekstrand & Tropp, 1990; Ekstrand et al., 1990; Engström et al., 1991). Inklaar (1994) in a review of the literature concluded that injury during games tended to be 3-4 times higher than the risk during practice. Appendix 5 reports an incidence rate per 1000 playing hours of game and practice, respectively for adults 2-24 and 2-8 and for youths 8-10 and 1-2. Unfortunately, a limitation in comparing competition versus practice injury rates, is that injury details are often less reliably kept at practice.

### 5.1.7 Gender

Inklaar (1994a) in a review of the literature reported that female soccer players showed a higher incidence of injury than male soccer players in youths (Schmidt-Olsen et al., 1985; Maehulum et al., 1986; Backous et al., 1988; Backx et al., 1989) and for elite senior players (Engström et al., 1991).

### 5.1.8 Age

The incidence of soccer injuries also appears to increase with age (van Galen & Diederiks, 1990; Hoff & Martin, 1986; Schmidt-Olsen et al., 1985; Schmidt-Olsen et al., 1991). It has been speculated that this finding may be associated with increased strength and body size leading to higher speeds and higher impact forces at collisions.

## 5.2 Victorian Emergency Department Presentations

The Victorian Injury Surveillance System (VISS) collects detailed information from emergency department presentations to Victorian public hospitals. The collection began in 1988 with data collected from 7 campuses of 5 Victorian public hospitals[1]. Since October 1995 this collection

[1] Royal Children's Hospital, Western Hospital - Footscray and Sunshine Campuses, Preston and Northcote Community Hospital, Royal Melbourne Hospital and Latrobe Regional Hospital - Traralgon and Moe campuses

has been extended to 25 hospitals, 23 of which are currently contributing data[2], with various levels of completeness and accuracy.

Emergency department data from both the original VISS data base and the new VEMD data has been combine to recorded 24, 800 sporting injuries during this period, 10% of which (n = 2251) relate to soccer. It should be noted that this combined database is a non representative sample of emergency department presentations to Victorian Public Hospitals.

Fifty-seven percent of child soccer injuries occurred during play of an informal or unspecified nature, compared with only 30% of adult cases for soccer of the same nature. Sixty percent of adult cases occurred during formal outdoor competition. A further 10% of adult and 3% of child injuries occurred while playing indoor soccer (Table 1).

**Table 1: Soccer injuries by age and nature of match**

| Soccer type | Adult | | Children | | Total | |
|---|---|---|---|---|---|---|
| | N = | % | N = | % | N = | % |
| Formal outdoor | 654 | 60 | 476 | 40 | 1130 | 50 |
| Informal/NS outdoor | 326 | 30 | 667 | 57 | 993 | 44 |
| Indoor | 103 | 10 | 31 | 3 | 134 | 6 |
| Total | 1083 | 100 | 1174 | 100 | 2257 | 100 |

*Source: Victorian Injury Surveillance System, Emergency Department Presentations 1988 to 1996*

An overview of the major outcomes associated with all types of child and adult soccer injuries are shown in tables 2 and 3.

[2] Alfred Hospital, Angliss Hospital, Austin and Repatriation Medical Centre, Ballarat Base Hospital, The Bendigo Hospital Campus, Box Hill Hospital, Dandenong Hospital, Echuca Base Hospital, The Geelong Hospital, Goulburn Valley Base Hospital, Maroondah Hospital, Mildura Base Hospital, Monash Medical Centre, Mornington Peninsula Hospital, Preston and Northcote Community Hospital, Royal Children's Hospital, Royal Victorian Eye and Ear Hospital, St Vincent's Public Hospital, Wangaratta Base Hospital, Warrnambool and District Base Hospital, Western Hospital, The Williamstown Hospital and Wimmera Base Hospital.

**Table 2: Soccer Injury Presentations, <15 years**

| | Outdoor | | | | Indoor | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | Informal | | Formal | | | | | |
| | N | % | N | % | N | % | N | % |
| **Body region** | | | | | | | | |
| - upper limb | 306 | 44 | 214 | 36 | 15 | 44 | 535 | 44 |
| - lower limb | 247 | 36 | 178 | 43 | 13 | 38 | 438 | 36 |
| - head and face | 79 | 11 | 57 | 11 | 4 | 12 | 140 | 11 |
| **Nature of injury** | | | | | | | | |
| - fracture | 228 | 33 | 156 | 31 | 9 | 26 | 393 | 32 |
| - superficial | 203 | 29 | 132 | 27 | 11 | 32 | 346 | 28 |
| - strain/sprain | 159 | 23 | 125 | 25 | 11 | 32 | 295 | 24 |
| **Admission to hospital** | 48 | 7 | 46 | 10 | 1 | 3 | 95 | 8 |
| **Mechanism** | | | | | | | | |
| - fall | 260 | 39 | 129 | 27 | 7 | 23 | 396 | 34 |
| - collision with other player | 133 | 20 | 174 | 37 | 3 | 10 | 310 | 26 |
| - hit by ball | 92 | 14 | 43 | 9 | 7 | 23 | 142 | 12 |
| - over-exertion | 69 | 10 | 44 | 9 | 5 | 16 | 118 | 10 |

*Source: Victorian Injury Surveillance System, Emergency Department Presentations 1988 to 1996*

**Table 3: Soccer Injury Presentations, 15+ years**

| | Outdoor | | | | Indoor | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | Formal | | Informal | | | | | |
| | N | % | N | % | N | % | N | % |
| **Body region** | | | | | | | | |
| - lower limb | 361 | 53 | 187 | 55 | 74 | 70 | 622 | 55 |
| - upper limb | 105 | 15 | 71 | 21 | 14 | 13 | 190 | 17 |
| - head and face | 96 | 14 | 29 | 9 | 10 | 9 | 135 | 12 |
| **Nature of injury** | | | | | | | | |
| - strain/sprain | 199 | 29 | 125 | 37 | 49 | 46 | 373 | 33 |
| - fracture | 176 | 26 | 84 | 25 | 23 | 22 | 283 | 25 |
| - superficial | 142 | 21 | 74 | 22 | 22 | 21 | 238 | 21 |
| **Admission to hospital** | 56 | 9 | 22 | 7 | 6 | 6 | 84 | 8 |
| **Mechanism** | | | | | | | | |
| - collision with other player | 298 | 46 | 76 | 23 | 39 | 38 | 413 | 38 |
| - fall | 115 | 18 | 89 | 27 | 19 | 18 | 223 | 21 |
| - over-exertion | 99 | 15 | 73 | 22 | 31 | 30 | 203 | 19 |

*Source: Victorian Injury Surveillance System, Emergency Department Presentations 1988 to 1996*

### 5.2.1 Formal Soccer (outdoor)

Sixty percent of adult and 40% of child soccer injuries occurred during formal outdoor competition. The scenarios surrounding these cases will now be considered.

#### *5.2.1.1 Child Injuries ( n = 476)*

Of the 476 cases of children's formal outdoor soccer injuries, most players (85%) were aged 10 to 14 years and 93% were male.

Sixty-eight percent occurred in areas for organised sport, such as soccer ovals and reserves. Another 27% of cases occurred at schools and 3% at parks. Ten percent of injuries occurred during training or practice.

Thirty-seven percent of injuries were the result of a collision with another player, almost 10% of these occurred during a tackle. Another 27% of injured children fell (6% of these tripped over another player), 9% over-exerted, 9% were hit by the ball and 3% were pushed. Six children were involved in collisions with the goal post (ie. ran into, pushed into).

The admission rate for formal children's soccer injuries was 10%. Twenty-six percent of injured children were treated without referral, 19% were referred to an outpatients clinic, 16% required review in the emergency department and 14% were referred to a general practitioner.

VISS can record up to 3 separate injuries per case. As a result there were a total of 496 separate injuries sustained by the 476 injured players. Forty-four percent of the total injuries were to the lower limbs, particularly strain/sprain of the ankle (7% of total), strain/sprain of the knee (5%) and fractures of the tibia/fibula (5%). A further 36% of injuries were to the upper limbs, particularly fractures of the radius/ulna (9%) while sprain/strains of the wrist and intracranial injuries each accounted for another 4% of the total number of injuries.

#### *5.2.1.2 Adult Injuries ( n = 654)*

Ninety-six percent of the 654 adult players injured while playing formal outdoor soccer were male. Thirty-five percent of players were aged 15-19 years, a further 30% were aged 20-24 years while 16% were aged 25-29 years.

Eighty-four percent occurred at areas for organised sport, 9% at parks/recreational areas and 6% at schools. Four percent of injuries occurred during training or practice.

Forty-six percent of injuries occurred when the player was involved in a collision with another player (14% of these occurred during a tackle). Another 18% of injured players fell, 15% over-exerted and 5% were hit by the ball. Two players were injured when they collided with the goal posts and one when they were heading the ball.

The admission rate for formal adult soccer injuries was 9%. A further 28% of players were referred to a general practitioner, 25% were treated without referral, 19% were referred to the outpatients department and 12% were to be reviewed in the emergency department.

VISS can record up to 3 separate injuries per case. As a result there were a total of 678 separate injuries sustained by the 654 injured players. Injuries to the lower limbs accounted for 53% of total injuries, particularly strained ankles and knees (12% and 9% respectively of the total number of injuries), fractures of the tibia and fibula accounted for a further 7% of injuries. The upper limbs accounted for a further 16% of total injuries, particularly fractures to the bones in the hand, and another 14% of injuries were to the head and face.

### 5.2.2 Informal Soccer (outdoor)

There were a further 667 child and 326 adult soccer injuries which related to informal soccer play. These cases represent 57% of all child soccer injuries recorded by VISS and 30% of adult soccer injuries.

#### *5.2.2.1 Child Injuries (n = 667)*

Three quarters of child participants were aged 10-14 years and 91% of injured participants were male.

More than half (51%) of children's informal soccer injuries occurred at school, other common locations for these injuries were home (17%), parks/recreation areas (6%) and soccer grounds (6%). Seventeen percent of cases were unspecified as to the injury location.

The most common causes of these injuries related to falls, slips or trips (39%); collisions with another player (20%); being hit by the ball (14%), over-exertions (10%) and being pushed (3%). Poor surface conditions in the area of play contributed to 12 cases of injury.

The admission rate for these cases was 7%. Almost one third of injured children were treated without referral, 23% were referred to an outpatients department, 12% to a general practitioner. Review in the emergency department was required by 12% of injured players, while a further 12% required no treatment at all.

VISS recorded 694 separate injuries. Forty-five percent of the total number of injuries were to the upper limbs, particularly fractures of the radius/ulna (12% of total injuries), fractures of the hand, including fingers (6%), superficial injuries to the hand (4%) and fractures of the wrist (4%). Another 36% of injuries were to the lower limbs, particularly strain/sprain of the ankle (6%), strain/sprain of the knee (4%) and superficial injuries to the feet (4%).

#### *5.2.2.2 Adult Injuries ( n = 326)*

Ninety-three percent of adult informal soccer injuries were to males. Almost two-thirds of the adult informal injured players were aged less than 25 years.

Forty-four percent of injured players did not specify the location where the injury occurred. Of the remaining cases 18% were at soccer grounds, 16% at parks/recreational areas and 13% at schools.

Twenty-seven percent of injuries occurred when the player fell, 23% when they collided with another player and 22% resulted from over-exertions. Two more cases of injury were the result of collisions with soccer goal posts and 5 cases were caused by poor surface conditions.

The admission rate for adults sustaining informal soccer injuries was 7%. Twenty-eight percent of players were treated without referral. Referral to an outpatients department or general practitioner occurred in 26% and 22% of presentations respectively, while 11% required review in the emergency department.

Of the 340 separate injuries sustained 54% were to the lower limbs, particularly ankle sprains/strains (13% of total injuries sustained) and knee strains/sprains (10%). Another 20% of injuries were to the upper limbs.

### 5.2.3 Indoor Soccer

There were 134 (103 adults and 31 children) indoor soccer injuries recorded by VISS. Age and sex patterns mirrored those of outdoor soccer injuries.

Injuries resulted primarily from collisions with another player (31% of total), over-exertions (27%), falls (19%) or as the result of being hit by the ball (7%).

The admission rate was 5%. Thirty-one percent of injured players were treated without referral, 20% were referred to an outpatients department, 19% were referred to a general practitioner and 13% required review in the emergency department.

Sixty-two percent of injuries were to the lower limbs. Injuries to the ankles accounted for 28% of total injuries sustained, particularly strains and sprains represent (24% of the total of injuries). A further 9% of injuries were strain/sprains of the knee and a further 20% of injuries were to the upper limbs.

## 5.3 Conclusion

Injury data from a collection of cases from Victorian hospital emergency departments is generally not inconsistent with that described in the literature.

**Table 4: Epidemiology of soccer injuries**

| | CHILD | | ADULT | |
|---|---|---|---|---|
| | VISS data | Literature range | VISS data | Literature range |
| **Body region** | | | | |
| upper limb | 44% | 4-43% | 53% | 64-93% |
| lower limb | 36% | 38-89% | 15% | 6-24% |
| head & face | 11% | 4-13% | 14% | 4-22% |
| **Nature of injury** | | | | |
| fracture | 33% | 6-32%* | 29% | 36-71% |
| superficial | 29% | 32-47% | 26% | 1-21% |
| sprain/strain | 23% | 22-59% | 21% | 2-25% |

** includes dislocations*

The proportions of injury reported for both child and adult injuries was generally within the ranges viewed in the literature in terms of body region and nature of injury. Comparison of the data must be made with caution, given the presentation of data in various forms along with differences in the study population, data collection methods and injury definitions.

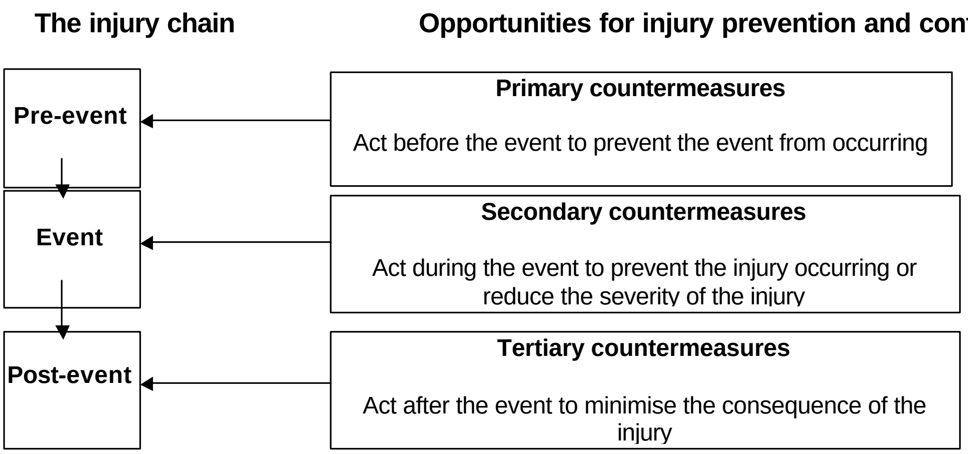
# 6. AN OVERVIEW OF INJURY COUNTERMEASURES FOR SOCCER

Injuries are considered to result from a culmination of a set of circumstances and pre-existing conditions that may best be understood as a chain of events: pre-event, event and post event (Robertson, 1983). Injury countermeasures are measures that can "counter", that is prevent or reduce, the risk of injury. A number of researchers have described how countermeasures should be targeted at the different links in the chain of events leading to injury (Haddon, 1972; Ozanne-Smith & Vulcan, 1990; Watt & Finch, 1996).

## 6.1 Primary, secondary and tertiary countermeasures

Such injury countermeasures can be equated with primary (pre-event), secondary (event) and tertiary (post-event) prevention in the chain of events leading to an injury (Figure 4). Primary countermeasures act before an event or incident that could potentially lead to injury, to prevent the event from occurring in the first place. Secondary countermeasures act during the event, to prevent the injury occurring or to reduce severity of the injury. The third level of countermeasures act after the chain of events/incidents leading to injury and help to minimise the consequences of injury.

***Figure 4: Countermeasure opportunities in the injury chain***




*Source: Watt & Finch (1996)*

There are a multitude of factors that contribute to the risk of injury in soccer players. Generally, more than one factor is involved in each injury. Consequently there are numerous countermeasures aimed at the primary, secondary or tertiary level which can be considered to prevent these injuries. These are summarised in Table 1.

**Table 5: Soccer injury potential countermeasures**

| Primary | Secondary | Tertiary |
|---|---|---|
| adequate water intake<br>attention to biomechanics<br>coach education<br>footwear<br>modified rules<br>nutrition<br>orthotics<br>playing environment<br>pre participation screening<br>pre-season conditioning<br>taping and bracing<br>removable goal posts<br>technique<br>training<br>UV protection<br>warm-up | goal post padding<br>environment<br>footwear<br>control foul play<br>protective equipment<br>• helmets<br>• shin guards<br>• mouthguards<br>• gloves<br>• padded shorts<br>surface | availability of first aid equipment<br>prompt first aid<br>rehabilitation<br>return to play when fit<br>rest, ice, compression, elevation, referral, transfer<br>taping and bracing |

## 6.2 Intrinsic and extrinsic factors

Sports injury risk factors can also be described as intrinsic or extrinsic factors (Kannus, 1993). Intrinsic, or internal, factors are related to levels of physical and mental health of the athlete. Extrinsic, or external, factors are those which impinge externally on the athlete's performance. Different countermeasures are used to address the intrinsic and extrinsic risk factors. Table 2 re-categorises the countermeasures given in Table 1 into intrinsic and extrinsic factors. Typically, the intrinsic factors are addressed by primary prevention activities. Attention to extrinsic factors involves primary, secondary and tertiary levels.

**Table 6: Intrinsic and extrinsic factors associated with soccer injury potential countermeasures**

| Intrinsic factors | Extrinsic factors |
|---|---|
| biomechanics correction<br>nutrition<br>orthotics<br>pre participation screening<br>pre-season conditioning<br>rehabilitation<br>technique<br>return to play when fit<br>functional stability<br>previous injury<br>fitness to return to play | adequate water intake<br>coach education<br>playing equipment<br>footwear<br>foul play<br>modified rules<br>playing environment<br>protective equipment<br>rehabilitation<br>surface<br>training<br>UV protection<br>warm-up<br>taping/bracing<br>shin guards<br>first aid, RICE, referral, transfer |

In the next section, the literature assessing the effectiveness of the various countermeasures for the prevention of soccer injuries listed in Table 1 and Table 2 is reviewed. For each countermeasure, the rationale for its use as a safety measure is presented, together with a critical review of the extent to which it has been fully evaluated.

Overuse injuries are common and attention to technique is an important countermeasure during soccer activities. However, in soccer, collision type injuries are also common. These include collisions with the game surrounds (eg. goals) or other players. Protective equipment and game rules have developed largely to prevent these injuries. Other countermeasures such as modified rules, attention to environmental factors, etc. have more general relevance across sports.

## 6.3 Preventing Overuse Injuries

To succeed at the elite level, soccer players, like most athletes today, are expected to train harder and longer and to commence at an earlier age. It is, therefore, not surprising that physicians are diagnosing an increasing number of overuse injuries, as the hours of repetitious practice produce a gradual deterioration in the functional capacity of the body. An overuse injury results from an accumulation of stresses to the involved tissue - bone, ligaments or tendons. The tissue and anatomic sites of an overuse injury may vary but according to Herring and Nilson (1987) the cause is still the same: repetitive episodes of trauma overwhelming the body's ability to repair itself.

Overuse injuries may be associated with the forces and repetitive nature of the gait cycle, as running is a key component of soccer. Alternatively, an overuse injury could be the result of a previous injury for which the body compensates, by increasing the stress on another part of the body, eventually leading to tissue breakdown and overt injury at the vulnerable site. Overuse injuries in soccer players usually begin with pain and stiffness. Depending on the severity, the player will suffer pain and stiffness at the beginning, during or after the activity, or a combination of these. Continuous pain and stiffness will eventually lead to a cessation of competition or training. Once an overuse injury develops, the condition remains until physiological equilibrium is re-established between the stresses of athletic activity and the body's healing ability (Ting, 1991).

Training, technique, footwear, surface, rehabilitation, warm-up and conditioning are all factors contributing to overuse injuries with numerous primary, secondary and tertiary factors playing a role in prevention (refer Table 4). Due to the range of factors contributing to overuse injuries, reference also needs to be made to all the countermeasures reviewed in other sections of this report.

In reviewing the literature, Inklaar (1994) indicated that youth players sustained more contusions and fewer overuse injuries than senior players. No difference was recorded between senior female soccer players and senior males. Inklaar (1994) reported that a higher percentage of overuse strains were registered in professional soccer than amateur soccer. While specifically about two-thirds of injuries had a traumatic origin and about one-third of injuries concerned overuse.

### 6.3.1 Recommendations for further research, development and implementation

- More research into the aetiology of overuse injuries in soccer needs to be undertaken.
- The role of conditioning (both to improve strength and flexibility) in the prevention of overuse injuries should be further explored.
- Soccer players should be educated about the risk and severity of the consequences of overuse injuries.

## 6.4 Lower Leg Injuries and Technique

The nature of the game of soccer, in which players make hard cuts, sharp turns off a planted foot, and intense contact with the ball and other players, along with the essential underlying components of soccer: running and kicking, indicate the vulnerability of the lower extremities (Larson et al., 1996).

As stated in section 5, the majority of soccer injuries occur to the lower extremities (refer Appendix 3 and 4). A variety of extrinsic and intrinsic risk factors for lower leg injuries in soccer players have been identified (Keller et al., 1987; Surve et al., 1994). Intrinsic risk factors include pathological knee ligamentous laxity, previous ankle sprain, leg weakness following previous injury, decreased flexibility, and inadequate rehabilitation (Keller et al., 1987). Extrinsic factors including inadequate equipment, footwear, poor field conditions, and foul play. Knee and ankle injuries each represent about one-fifth of all soccer injuries regardless of age.

### 6.4.1 Ankle

Ankle joint injuries are among the commonest that occur in sport (Ekstrand & Tropp, 1990). Ankle sprains, in general, are not as severe as many other possible injuries, but can cause recurrent injuries through a mechanism of chronic instability (Aglietti et al., 1994).

Ekstrand and Tropp (1990) reported that soccer players with a previous ankle injury were 2.3 times more likely to suffer another ankle injury than those without a previous history of ankle sprain. Whereas, only 10% of the previously uninjured players would sustain an ankle sprain.

Similar findings were reported by Nielsen and Yde (1989), who found that 59% of ankle injuries occurred in players with a history of ankle sprain. Ankle sprains occurred equally during tackling and running. However, 80% of players had their first ankle sprain during tackling, all players injuries were sustained during tackling, and all players whose injuries were sustained during running had a previous history of ankle sprains.

Aglietti et al. (1994), found that of the 27% of ankle injuries reported, the majority (70%) resulted from inversion, without any contact. The majority of ankle injuries presenting to emergency departments were sprains/strains (Routley & Valuri, 1993). Most of the ankle sprains occurred when the player was kicked in the ankle by another player, when the player fell or when the player landed awkwardly after jumping or running.

A number of measures have been proposed to reduce the incidence of ankle sprains in soccer players. These include heel cord stretching exercises, adequate warm-up, and using an external support to decrease inversion and eversion range of movement of the ankle joint (taping or a semirigid orthosis) (refer section 7.5.2) (Ekstrand & Tropp, 1990; Keller et al., 1987; Surve et al., 1994; Tropp et al., 1985). Attention to shoe selection and the condition of the playing surface should also be considered as important factors in reducing ankle injuries.

### 6.4.2 Knee

Knee injuries are usually the most severe lower leg injury, particularly considering the prolonged absence from sport that they cause (Aglietti et al., 1994).

One third of injuries sustained by three elite Swedish soccer teams during a one year period occurred to the knees (Engström et al., 1990). At follow-up, 9 to 18.5 months after injury, 4 of the 12 players with major knee injuries had returned to play at the elite level. The others had either been transferred to a lower division or were still in rehabilitation.

Nielsen and Yde (1989) found that more than half of knee injuries occurred during tackling and resulted in the longest time of absence. The majority of knee injuries reporting to emergency departments occurred when the player made contact with another player ie. during a tackle, collision or being kicked/struck (Routley & Valuri, 1993). Sprains and strains accounted for two thirds of these injuries.

A number of preventative measures have been proposed to reduce knee injuries. These include stretching exercises, adequate warm-up, and using an external support (taping or a semirigid orthosis), along with attention to shoe selection and the condition of the playing surface.

In a prospective controlled study of 600 soccer players in 40 semi-professional or amateur teams, over three soccer seasons, Caraffa et al (1996) studied the possible prevention of acute cruciate ligament (ACL) injuries by gradually increasing proprioceptive training on four different types of wobble-boards during three soccer seasons. Three hundred players were instructed to train 20 min/day with 5 different phases of increasing difficulty. A control group of 300 players from comparable teams trained "normally" and received no special balance training. With the use of KT-1000 measurements, magnetic resonance imaging or computer tomography, and arthroscopy diagnosis it was found that proprioceptive training could significantly reduce the incidence of ACL injuries in soccer players.

### 6.4.3 Shin Guards

This review has found that collision injuries are commonly reported in the literature. A player versus player contact commonly occurs when players are trying to kick the ball and instead impact each other. This scenario can result in soft tissue injuries as well as fractures to the upper or, more commonly, to the lower extremities particularly the shins (Bir et al., 1995).

The problem with establishing the incidence of shin related injuries, is that the majority of epidemiological soccer literature categorises injuries in terms of lower leg, and does not stipulate any details (ie. muscle tear, sprain, strain or a fracture of soft tissue injury).

However, Ekstrand (1992) reported that only 30% of players used shin guards during practice. A lack of, or inadequate use of, shin guards was associated with 4% of lower leg injuries sustained in the senior amateur soccer players surveyed.

A prospective study of injuries during participation in a 4.5 day soccer camp for youths aged 6 to 17 years, revealed that of the players who wore shin guards, only 2.2% sustained an injury to the lower leg compared with 10.5% of the players not wearing shin guards at the time of injury (Backous et al., 1988). The authors concluded that failure to wear shin guards markedly increased the proportion of lower leg injuries.

Shin guards are frequently reported as being insufficient in size, thereby protecting too small an area, and consequently their shock absorbing qualities are inferior. The protective capacity of shin guards was first studied by Von Laack (1985) who tested commercially available shin guards on a dummy leg. Results indicated that the shin guard would be effective mainly in preventing abrasion injuries.

Since then shin guard design has developed dramatically. A comprehensive evaluation of the effectiveness of shin guards in attenuating the forces which can lead to lower extremity injuries was conducted by Bir et al. (1995). Impacts similar to that of one player kicking another were delivered to the anterior tibial region of a 5th percentile Hybrid III female dummy and load forces recorded. Load forces were reduced by 41.2-77.1% with the utilisation of shin guards. Even at extreme temperatures, the guards were found to be effective. The authors concluded that the use of shin guards would attenuate the force of impact to the tibia and thus reduce the risk of injury (Bir et al., 1995). This investigation, however, had limitations as it was preformed in a laboratory setting rather that in the field. Also the model being used in this test does not provide an accurate representation of all players involved in soccer, rather a 5th percentile hybrid III female dummy is reported as being representative of a 10-12 year old child.

It is however the consensus view of numerous authors (Gare, 1987b; Greenie & Hillman, 1990; Larson et al., 1996; Shaper et al., 1994) that shock absorbent, anatomically shaped shin guards that cover a large area of the lower leg can prevent injuries to the shin in soccer players.

The International Federation of Football Association (FIFA) introduced compulsory wearing of shin pads during both competition and training in 1990. The FIFA's 'Laws of the game: players' equipment' state:

- The basic compulsory equipment of a player shall consist of a jersey or shirt, shorts, stockings, shin guards and footwear.
- Shin guards, which must be covered entirely by the stockings, shall be of a suitable material (rubber, plastic, polyurethane or similar substance) and shall afford a reasonable degree of protection.

Prior to FIFA regulations the voluntary use of shin guards was limited.

The average cost of shin guards in Australia is AUS$35-45. After purchase, shin guards need to be heated, fitted, cut and shaped to fit the individual's shape.

### 6.4.4 Footwear

There are hundreds of styles of soccer boots, produced by various manufacturers in a range of colours and prices, in stores today. As a soccer player takes about 15,000 steps during a game, the quality of their footwear is clearly significant (Ekstrand, 1982). When a soccer player selects a boot it must provide cushioning, support and stability, and must maintain reasonable flexibility, softness, and lightness (Cook et al., 1990). The modern soccer shoe provides little protection, very little support and no cushioning (Monto, 1993; Inklaar, 1994). Consequently, the soccer player is exposed to great stresses and forces.

#### *6.4.4.1 Footwear faults*

Ekstrand and Gillquist (1982) studied 180 male soccer division players, and ascribed 13.3% of injuries to be the result of inferior footwear. Two-thirds of these were classified as overuse type injuries. These injuries predominantly were as a result of a combination of poor playing surfaces and inferior shoes. The traumatic injuries, such as knee sprains, were usually due to twisting of the knee when the foot wearing a shoe with screw in cleats was fixed to the ground (Ekstrand, 1982)

X-rays of the feet and ankles of the US men's senior National and Olympic soccer teams, found that 97% of the players had extra bony growths such as osteophytes (bony spurs) due to repeated micro- and macrotrauma leading to very high impact forces and stresses (Monte et al., 1993; Inklaar, 1994).

#### *6.4.4.2 Attention to impact forces*

Epidemiological evidence has indicated that 59-93% of all soccer injuries are to the lower extremities (Appendix 3). The logical approach to prevent these injuries would, therefore, be to attenuate the impact forces - for example by using shock absorbing shoes, shoe inlay orthoses or even good socks (van Mechelen, 1995).

From a general review of the literature on the prevention of injuries in sport, Cross (1993) concluded that correct, suitable and safe footwear plays an important role in injury prevention. Cross (1993) also argued that an athlete's footwear must be able to absorb shock, while maintaining enough stability to prevent excessive pronation (rolling in of the foot). The material of the midsole cannot be too heavy or too inflexible, but must still provide much of the shock absorption. Taking these factors into consideration, shoes are now designed with gel or air inserts in the midsole in order to provide lighter, yet efficient, shock absorption qualities. Traction in wet and slippery conditions requires good studs on the outer sole of the shoe. The inner sole should be comfortable, cupping the normal heel contour (the rigid material within the counter) during landing and supporting the arch of the foot. The toe box of the shoe should leave sufficient room for foot movement. Blisters, corns, loss of toenails, and so on, can be the result of a too tight fit. It is also important that the material used in manufacturing sports shoes allows the feet to "breathe", thus reducing moisture and helping prevent blisters (Cross, 1993).

Pronation is a natural function of weight bearing exercise. Excessive pronation, however, is a problem often associated with lower limb overuse injuries, including plantar faciitis, Achilles tendinitis, shin splints (ie. strain of the long flexor muscle of the toes, causing pain along the shin bone) and runner's knee. Greater stability of the foot can help prevent hyperpronation (excessive rolling of the foot). This is achieved in shoe design by including a heel counter (a rigid material within the exterior wrap around the heel) that is firmly connected to the midsole. This wedges the midsole and is made with materials of greater consistency (firmness) than those on the lateral side (away from the midline) (Cross, 1993).

It is generally believed that the potential aetiological factors of impact forces and foot pronation, can be influenced by the sport shoe (Cook, 1990). The corollary to this is that shoe design can be used to prevent injury.

Sandrey et al., 1996 outlined the importance of selecting soccer shoes for excessive pronators, based on the characteristics of the individual's foot, in a study of 40 subjects using various measurement test and multivariant analysis. They concluded that foot length should not be the only consideration in determining the proper fit of the shoe in excessive pronators. Static and dynamic measurements of the foot should include metatarsal width, fifth metatarsal length and heel width.

In a study by Jørgensen & Ekstrand (1988) the significance of heel pad confinement for the shock absorption at heel strike was investigated. It was concluded that shock absorbency at heel strike can be increased significantly by heel support, with highest effect in persons with low heel pad shock absorbency, both in shoes with high and low shock absorption. Given the high incidence of lower extremity injuries to soccer players, Jørgensen and Ekstrand (1988) suggested that a doubling of shock absorption in the soccer shoe could markedly decrease the body loading and overuse injuries. They further indicated an increase in performance could be expected as such a claim has been seen in other sports.

It seems evident that a properly fitting soccer shoe, providing cushioning, support and stability can play an important role in shock absorption, and as a consequence injury prevention (Cook et al. 1990). However, there is also evidence which suggests that modern athletic footwear provides poor protection from lower extremity overuse injuries and may cause chronic overloading (Robins and Gouw, 1990).

Robbins and Gouw (1991) investigated twenty male subjects from a university population, to examine how plantar tactile events (ie. when the sole of the foot touches the ground) affect perceived sole discomfort. They found that people who performed activities involving high impact (absorbing) footwear, currently promoted as offering protection in this environment, are at high risk for injury. In the natural situation (ie. barefoot and natural surfaces) the impact is sensed and, through impact moderating behaviour, is maintained at a safe level. An inadequate understanding of the physiology of human impact control has resulted in footwear which makes chronic overloading inevitable, by providing plantar comfort to the wearer, even when enormous vertical impacts are experienced. These observations are based on the results of laboratory tests, which may not necessarily be representative of a soccer environment.

The question still remains, therefore, as to whether specifically designed athletic shoes reduce overall the risk of injury or merely transfer the risk of foot injury to other areas of the lower extremity or even have the potential to cause injuries.

Maguire (personal communication), a specialist in Rheumatology and Sports Medicine attributes a significant decrease in problems in relation to the foot to improved footwear in soccer. These include problems such as toenail haematoma, ingrown toenail problems, primary forefoot metatarsalgia, plantar fasciitis, heel spur pain and often acute jarring type injuries to the mid and subtalar joints.

#### *6.4.4.3 Relationship between footwear and playing surface*

High friction between shoes and surface may produce excessive forces on the knees and ankles; too little friction, however, may be the reason for slipping, which affects performance negatively and may cause injuries (Ekstrand & Nigg, 1989; Aglietti, 1994). Soccer is characterised by sprinting, stopping, cutting and pivoting situations where shoe-surface relations are essential and frictional resistance must be within an optimal range (Ekstrand & Nigg, 1989; Inklaar, 1994). Therefore when selecting footwear it should be realised that there is interaction between the foot and the shoe and between the shoe and the playing surface (Hlobil et al., 1987; Ekstrand & Nigg, 1989; Aglietti et al., 1994).

There is a noticeable lack of data for comparing the relative safety of different shoe and cleat designs. Nevertheless, it is the opinion that screw in cleats are associated with a higher risk of ankle and knee injuries. Moulded cleat and ribbed sole designs may be safer (Keller et al., 1987)

A 3 year prospective study was initiated by Lambson et al. (1996) to evaluate torsional resistance of modern football cleat designs and the incidence of surgically documented anterior cruciate ligament (ACL) tears in 3119 high school football players wearing four different cleat types. The four cleat designs were:

- edge, longer irregular cleats place at the peripheral margin of the sole with a number of smaller pointed cleats positioned interiorly (n=2231);
- flat, cleats on the forefoot are the same height, shape and diameter, such as found on the soccer-style shoe (n=832);
- screw-in, seven screw-in cleats of 0.5 inch height and 0.5 inch diameter (n=46) and;
- pivot disk, a 10cm circular edge is on the sole of the forefoot, with one 0.5 inch cleat in the centre (n=10).

The results showed that the 'edge' design produced significantly higher torsional resistance than the other designs ($P<0.05$) and was associated with a significantly higher ACL injury rate than the other three designs combined (Lambson et al., 1996).

In a review by Ekstrand and Nigg (1989), on the role that surface type plays in soccer, playing with cleat shoes on artificial surfaces was found to increased the rate of injury.

The playing surface must be taken into serious consideration when selecting appropriate footwear. Forces and moments acting on the body are changed on different surfaces, various weather conditions and by using different type of shoes (Nigg & Segesser, 1988; Inklaar, 1994). Consequently the incidence of injury may be partly dependent on the player, the surface and the footwear.

### 6.4.5 Recommendations for further research, development and implementation

- Studies are required on the causes and prevention of lower leg injuries. Research questions still to be answered included:
  - Which features of footwear are protective against soccer injuries?
  - Where should the balance lie between foot protection and stabilising effects of footwear and flexibility of shoes etc.?
  - What is the interaction between footwear and specific playing surfaces?
  - Do cushioning effects of footwear mask longer term damaging effects?
- Research studies need to take into account measures of exposure such as hours played, hours of training, position on the field etc.
- Evidence on the effects of interventions between footwear and surfaces should be reviewed with reference to other sports.

- Where the effectiveness of countermeasures have been proven and regulated eg. shin guards, enforcement at all levels of the game during practice and competition should occur.
  - Shin guards and footwear should be further and continually developed.
  - Equipment such as shin guards and footwear should be fitted with professional advice.
  - The use of wobble board training should be encouraged.

## 6.5 Head Injuries

### 6.5.1 General head injuries

While the vast majority of soccer injuries occur to the lower extremities, injuries to the head and neck also present regularly. The range of the total injuries attributable to the head, spine and trunk areas are 4-22% in adults and 9-26% in youths (refer appendix 3 and 4). Goalkeepers have been shown to have more head, face, neck and upper extremity injuries than lower extremity injuries (Inklaar, 1994a). While some studies report an increased incidence of upper head, face and neck injuries in youth soccer players (Inklaar, 1994a; Maehlum et al., 1986), other studies and reviews have not reported such differences (Inklaar, 1994a; Schmidt-Olsen et al., 1985; Schmidt-Olsen et al., 1991) .

The most common way soccer players sustain head injuries is through heading the ball (particularly if they use incorrect technique), forcefully kicked ball strikes to the head and as a result of head to head contact, most often when two players attempt to head the ball simultaneously (Fields, 1989; Larson et al., 1996). Common head injuries resulting from these mechanisms include lacerations and concussion (Larson et al., 1996).

Unlike injuries to the lower extremities, injuries to the head and neck have greater potential to be catastrophic (Cantu, 1991; Mueller, 1991). Largely due to the incapability of neurological tissue to regenerate.

Deaths resulting from impacts with a soccer ball are infrequent. The National Health and Medical Research Council (NHMRC) (1994) in their report on football injuries to the head and neck produced details of only two head/soccer related deaths. One death was reported in 1993 in Mudgee, NSW, when the Under 12s played a soccer grand final. The goal keeper dived on a ball and received a kick in the head which was fatal. The second death in 1992 resulted from a goal post falling on the head of a junior player (see also goal posts 6.7).

### 6.5.2 Heading technique

As indicated, one of the most common ways a soccer player sustains head injuries is through heading the ball. Using the head to direct the ball is a common feature in a soccer game, and this activity requires a high degree of skill and timing (Dods, undated). Heading involves an object, of given mass with a critical inertia imparting on the cranium, in effect, causing a minor traumatic event (Dods, undated).

Heading requires careful timing to make maximum use of the body’s momentum in striking the ball to either pass to another player, move the ball down field, control, score or clear a goal. Any part of the head may be legally used to strike the ball. However, the forehead is most common and highly recommended. Anatomically, the forehead is the strongest part of the skull. Using the forehead allows the eyes to follow through contact (Dods, undated). Using a validated mathematical model of the head and neck, Scneider and Zernicke (1988) demonstrated a potential increased injury risk based on standard head injury tolerance from angular head accelerations as compared to linear head accelerations. They also found lateral impacts imparted greater angular head accelerations than frontal impacts (Dods, undated).

Within the heading process, the neck muscles are also crucial in preventing serious injuries. To absorb the force of the impact with the ball and to prevent jarring at the neck, there must be transfer of momentum and, to achieve this, the head must be held rigid at impact (Dods, undated). Players should be instructed to tighten neck muscles and tuck the chin until the ball has been contacted. The head should be in line with the neck and trunk at the point of contact (Dods, undated).

Muscle tension keeps the cervical spine rigid, and this ensures that linear, not rotational, acceleration is imparted to the ball (NHMRC, 1994). Of course, if the ball is not struck correctly or the head receives a glancing blow, the speed and force of the ball can snap the head back if the neck is not braced. Consequently players should be correctly instructed from initial training and constantly reinforced throughout all training session.

Other factors in good heading technique include having the eyes open and on the ball throughout the movement, having strong neck muscles to maintain the rigidity of the neck at impact, having adequate trunk extension, strong hip flexors and abdominal muscles, and making sure the ball contacts with the forehead part of the cranium (Mawdsley, 1978).

### 6.5.3 The soccer ball and its relation to heading

Given that the process of heading involves head/ball impacts, considerable concern about the size and weight of the soccer ball has arisen. The old style leather balls were able to absorb water in wet conditions potentially increasing the weight by more than 20%. Consequently the greater weight increased the likelihood of a head injury. This problem is minimised as a modern soccer ball weighs about 400-450 grams and is made from plastic, which does not absorb water. The ball can reach speeds of 60-129km per hour (NHMRC, 1994; Tysvaer & Storli, 1989). A ball kicked with half power from a distance of 10 meters travelled 82km per hour and hit the head with an substantial impact (Kannagara, 1994; NHMRC, 1994).

Schneider and Zernicke (1988) recommended that head injury risk could be reduced by decreasing the mass ratio between the head and impacting body. In practical terms this means reducing the size of the ball as head size of the player reduces (Dods, undated). This is achieved by the use of three different sizes of soccer balls. Size 3 is used for children, Size 4 for juniors and women, and Size 5 for adult men.

Professional and international soccer players use expensive, hand-sewn soccer balls which are designed to meet all levels of competition. FIFA, the international governing body of soccer, places emphasis on meeting the demands of the professional players for correct ‘flight’ and ‘feel’. A good soccer ball is tested for bounce, flight, damping, air resistance, wear, water absorption and shape retention. With advancing techniques of different sizes and types of soccer balls the FIFA has endeavoured to minimise injuries (NHMRC, 1994).

### 6.5.4 Encephalopathy

A soccer player receives numerous impact forces between the head and the ball during their career. As the effect of repeated minor head injury is apparently cumulative, it has been suggested that an encephalopathy (degenerative disease of the brain) similar to that recorded in boxers may also occur in soccer players. Critical to this speculation, is the number of times a player heads the ball, the force associated and the characteristics of the ball itself.

A number of studies, based on the same group of soccer players have been conducted on the incidence of encephalopathy in soccer players (Tysvaer & Storli, 1989; Sortland & Tysvaer, 1989; Tysvaer et al., 1989; Tysvaer & Lochen, 1991). A report by Tysvaer (1992) brings a number of these findings together.

In a controlled study, Tysvaer et al. (1992) investigated 69 active soccer players and 37 former players of the Norwegian national team for the incidence of head injuries mainly caused by heading the ball. Three percent of the active and 30% of the former players complained of permanent problems such as headaches, dizziness, irritability, impaired memory and neck pain. Of the active players 35% and 32% of former players had from slightly abnormal to abnormal EEG readings compared with 13% and 11% of matched controls, respectively. The abnormal

EEG readings were more pronounced in the younger players. The former players were also subjected to cerebral computer tomography (CT), a neuropsychological examination and a radiological examination of the cervical spine. Of the players, one third were found to have central cerebral atrophy and 81% to have mild to severe (mostly mild to moderate) neuropsychological impairment. A significantly higher incidence and degree of degenerative changes than the matched control group was revealed by radiological examination of the cervical spine.

The authors concluded that these differences were as a result of repeated small head injuries during play, mainly connected with heading the ball. Unfortunately, only 69 of the total 96 players available from the six Norwegian First Division League Clubs were examined. Thirteen goalkeepers and 14 others who had a past history of head trauma unrelated to football were excluded. Within the general population, there are bound to be numerous soccer players with previous head injuries, who may as a result of heading be sustaining various degenerative diseases of the brain (encephalopathy). Given that these players continue to play soccer, their results would have proven interesting.

Tysvaer & Storli (1989) examined four active football players between the ages of 13 to 23 during and after ten minutes of correct heading and, although all four players developed a headache, there was no significant EEG changes. The authors suggested that blows to the head must be of a certain magnitude or that other factors as discussed like skill, impact direction and age must be of importance. It is also possible that cumulative rather than acute effects are identifiable by EEG.

From a comprehensive literature review, only two studies disputed neurological sequelae as a result of repetitive minor trauma from heading a soccer ball. Haglund and Eriksson (1993), in a study of 50 former amateur boxers and matched control of 25 former and active soccer players (who were selected because they were considered typical headers by their respective coaches), found no evidence of serious brain damage either with cerebral computed tomography, magnetic resonance imagery or neuro-psychological tests.(Dods, undated)

Jordan et al. (1996) felt that many studies (Sortland et al., 1989; Tysvaer & Lochen, 1991; Tysvaer & Sortli, 1989) had methodological problems, including a lack of suitable control groups, failure to control for acute head injuries, lack of valid screening for alcohol and failure to adequately blind the investigators. Therefore Jordan et al. (1996) designed a study eliminating these methodological problems to determine whether chronic encephalopathy occurs in elite, active soccer players resulting from repetitive heading of the soccer ball. Twenty of the 25 members of the US Men's National Soccer Team's training camp were compared with 20 age-matched male elite track athletes. Questionnaire analysis and magnetic resonance imaging demonstrated no significant difference between the groups. Symptoms and magnetic resonance for soccer players did not correlate with age, years of play or exposure index results of the number of headers. Reported head injury symptoms especially in soccer players did however correlate with a history of prior acute head injury. The authors of the study concluded that any evidence of encephalopathy in soccer players related more to acute head injuries received during playing soccer than from repetitive heading. The sample size in this study is rather small, and any differences would have to be large in order for the result to be significant.

The body of evidence, however, seems to suggest the opposite conclusion. Both animal and human studies have demonstrated that there is a cumulative effect of repeated minor head trauma, which can result in permanent brain damage (Mandel, 1989; Dods, undated).

The technique of heading the ball is a learned skill that requires practice before it can be mastered (Janda et al., 1997). Unfortunately, and particularly in children, learning involves several impacts which will occur using an improper format. Fifty-seven youth soccer players ranging in age from 10-14 were assessed using cognitive tests and the established heading exposure over a nine month period. Over this nine month period, females headed the ball an average of 33.75 times per player, while males headed the ball 131.78 times per player. An overall analysis of the data revealed there was no correlation between the number of times a child headed the ball and his/her cognitive testing scores. The youths reported the subjective symptoms of headaches (49%), blurred vision (5%), nausea (7%) and ringing in the ears (12%) occurred after heading the ball.

It is difficult to decide when a player should return to normal soccer activities after evidence of head injury or abnormal EEG. However, with the entrance of computerisation in medicine, there is a better and more objective assessment of head injury available with 'quantitative (Fried & Lloyd, 1992).

### 6.5.5 Helmets

The increasing popularity of soccer has contributed to concerns about player safety and discussions about the use of protective headgear by goalies. However, the use by other players has not been supported because it may change the essential nature of the game (Fields, 1989). The above studies suggestion of adverse reaction as a result of heading the ball, would support the use of helmets to decrease impact forces.

Superficially the remedy would be to prescribe helmets to all players (Fields, 1989). The analysis of Nowjack-Raymer and Gift (1996) found that only 4% of soccer players wore headgear. However as other studies have indicated, helmets may be used as a battering device or provide a false sense of security.

No studies evaluating the effectiveness of helmets in reducing soccer injuries have been reported. A prospective study to assess the protective effect of helmets would be difficult because of the low incidence of injury (Fields, 1989). Suggestions of padding goalposts as more appropriate countermeasures than the use of helmets do not solve the problem of repetitive heading injuries.

Janda (1997) reported that mild head injury occurring during the learning phase is notable. Consequently, he reported that the development of a prototype soccer helmet was necessary to reduce the force of impact to a significant level so that the symptomatology associated with mild head injuries could be minimised. The development of a prototype would need to take into consideration not only shock absorption characteristics, but also appearance and heat dispersion, important aspects to the voluntary acceptance and use. Janda has reported that his team is currently investigating a prototype.

### 6.5.6 Recommendations for further research, development and implementation

- Use only plastic coated balls
- Once water resistance qualities are lost, replace the ball.
- Use the appropriate sized ball for the age and gender group playing.
- Teach the player to head correctly and to maintain eye contact with the ball before and after contact is made (Dods, undated).
- Ensure the head and neck are kept rigid at impact and, once this basic technique has been acquired, only then progress to the standing jump and finally to the running jump (Dods, undated).
- The development of strong neck musculature, to keep the neck rigid at impact (Dods, undated).
- Strengthen the hip flexor and abdominal muscles for the ballistic action in the standing header.
- Children should be specifically trained and monitored in terms of correct heading technique

- Investigations should be made into the advantages and disadvantages of a lightweight helmet for soccer.
- Epidemiological research into the incidence of head injuries and associated factors should be undertaken
- Current evidence is not conclusive, thus further controlled studies of heading need to be conducted.
- The recommendations made by NHMRC should be endorsed.

## 6.6 Facial Injuries

Almost all sport can give rise to dental, mouth and face damage, though contact sports such as soccer, have been shown to have a relatively higher incidence of injury. There is an absence of FIFA rules for protection from orofacial injury and no mention of such devices in texts for coaches and athletes.

### 6.6.1 Eye injuries

Soccer, as a cause of eye injury, has received very little investigation, with the majority of the limited studies available focusing on all sports related eye injuries.

MacEwen (1987), surveyed all patients attending two eye infirmaries in England. A total of 246 cases of sport-associated eye injury was identified of which 44.7% were related to soccer. Specifically the ball was reported to cause 59% of soccer related eye injuries, while body contact either with self or opponent accounted for 32%. In a similar study, Gregory (1986) conducted an 18 month study of all sports injuries presenting to the Sussex Eye Hospital. In this sample population, soccer accounted for 20% of all severe eye injuries. Of these 79% resulted from being struck by the ball and the remaining 21% from other collisions.

A prospective cross-sectional survey of all eye injuries sustained during sporting activities treated at the Royal Victorian Eye and Ear Hospital in a two year period (Nov 1989 - Oct 1991) was conducted by Fong (1994). A total of 700 patients with 709 eye injuries, caused by sporting activities, was identified, representing 5% of all eye injuries. Of those injured through sporting activity, 5% were engaged in soccer. Fong (1994) also presented data from three previous international studies. Firstly the National Electronic Injury Surveillance System (NEISS) estimated that of the 1.7% of eye injuries occurring each year in relation to sport, soccer contributed to 4% (Vinger, 1991). In comparison, a Canadian ophthalmologist survey indicated that soccer was responsible for 6% of the total sports recorded eye injuries. While in a British eye hospital 33% of sports eye injuries occurred during soccer participation (Jones, 1988).

The problem with this data, is that it lacks appropriate denominators, such as number of participants involved in each sport in the catchment area for the data collection. A further limitation, is that these studies, have only reported on severe eye injuries, which have presented to emergency departments at well established eye hospitals. They therefore do not encompass the undoubtably large number of moderate or minor soccer related eye injuries, not presenting to hospitals.

From the point of view of preventing soccer injuries, these studies are also limited because they considered all sports and not specifically soccer. To progress soccer injury prevention, discussions of injury incidence and recommendations for prevention need to be limited to the soccer context.

### 6.6.2 Facial injuries

Facial fractures although not usually catastrophic, can result in long term morbidity and deformity and may require hospitalisation and surgery (Lim et al., 1993). Despite the obvious risks associated with soccer, little data exists on the extent and prevention of facial injuries in this sport.

One hundred and thirty seven patients with sports-related facial fractures were reviewed by Lim et al. (1993). These patients made up 16.3% of all facial fractures seen at the Department of Plastic and Reconstructive Surgery, Royal Adelaide Hospital, between June 1989 and June 1992. Soccer contributed to 5.1% of sporting facial fractures. This was fourth only to Australian Rules Football (52.6%), cricket (14.6%), rugby (5.8%). Again this study has not taken into account the number of injuries per number of sports specific players. Thus, the smaller contribution of soccer, may be as a result of being less frequently played than Australian Rules Football, rather than being less risky.

An earlier study in England examining dental and facial injuries over a five year period was conducted by Hill et al. (1985). Based on the data collected the frequency of facial injury was highest in rugby (27%), followed by cricket (20%) and soccer (20%). Result of this study also showed that the incidence of injury was highest in 20-29 year olds, followed by 30-39 year olds.

### 6.6.3 Dental injuries

Many soccer players do not wear mouthguards as a large amount of verbalisation is required. Thus dental injuries could be prevented to a greater degree. The analysis of Nowjack-Raymer and Gift (1996) found that only 7% of soccer players wore mouthguards. Clearly this is an area requiring further investigation.

### 6.6.4 Recommendations for further research, development and implementation

- Epidemiological research into the incidence and mechanisms of eye, dental and face injuries should be undertaken based on participation rates.
- Barriers to the use of mouthguards should be determined
- Mouthguards should be used by all players

## 6.7 Goal Posts

The Consumer Product Safety Commission (CPSC), reported that over a 16 year period (1979-1994), at least 21 deaths and an estimated 120 injuries involving falling soccer goal posts had occurred and been treated in US hospital emergency rooms (CPSC, 1995). These statistics do not encompass the numerous injuries that occur and do not receive emergency treatment. Nor do these statistics include the numerous collision injuries to the head, hands or other regions, that a goal keeper could incur while blocking a strike for goal.

The CPSC identified the cause of many of these serious injuries to be as a result of the soccer goals being tipped over onto the victim (CPSC, 1995). In these cases the deaths are usually a result of a blunt force trauma to the head, neck, chest or limbs from a 150-500 pound movable soccer goal.

In a previous report by the CPSC of 27 injuries (including 18 deaths) relating to falling soccer goal posts, 26 of the goal posts were made of metal; 23 of the goalposts were movable and one was permanently installed, and three were unknown (DeMarco & Reeves, 1994). Twenty-five of the injuries resulted from the goalpost falling forward striking the victim. Goalposts were not anchored in 18 cases and poorly anchored in one case. Three goalposts were anchored correctly and the status could not be determined in five cases.

Consequently the CPSC produced guidelines for movable soccer goal post safety (CPSC, 1995). These guidelines provide details on design and construction, anchoring, securing and counterweighing; and goal storage.

A report by the National Health and Medical Research Council of Australia on Football injuries of the head and neck reported one incident in 1992 which resulted in the death of a junior player from a goalpost falling and striking the head (NHMRC, 1994).

The FIFA, 'Laws of the game, guide for referees, July 1993, does not provide sufficient details in terms of anchoring or padding of goal posts. However, a report in the 'FIFA News' in September 1996, reported that for safety reasons, goals (portable and permanent) must always be securely anchored to the ground. Likewise, portable goals must be made of lightweight material and not left in place after use, but dismantled, removed and tied up or secured to a permanent structure. The recommendations were made by the FIFA prior to the amendment of Law I to occur in 1997. The FIFA also circulated a letter (letter no.503 dated 10, July, 1996) to notify all clubs and leagues of these instructions and to draw attention to the possibility of litigation.

However, as Janda et al. (1995) indicated, if the goal posts are made stationary to prevent tip over fatalities, the number of impact injuries could increase, since a immovable object is being placed on the field of play. When a player collides with a stationary goal post, it remains static, consequently the energy from the impact is absorbed by the player.

As a result, Janda et al. (1995) investigating the effectiveness of padded goal posts. This study was conducted by Janda et al. (1995), who investigated laboratory and clinical experiences with padded goal posts for preventing head injuries in soccer. Results of the laboratory testing phase indicated that the prototypes tested at all temperatures absorbed impact forces at a significantly higher level than the standard control goal posts. The prospective field testing of the study illustrated that no injuries were recorded during the 3-year trial period. Therefore Janda et al. (1995) concluded that padding stationary goal posts could be an effective mechanism for minimising impact related injuries.

The lack of epidemiological data in Australia in terms of goalpost related injuries and insufficient research into the pros and cons of fixed goal posts and goal posts padding, indicates the distinct need for greater controlled research in the area.

### 6.7.1 Recommendations for further research, development and implementation

- Ensure both portable and permanent goals are securely anchored to the ground.
- Ensure portable goals are made of a lightweight material.
- Dismantle, remove, tie up or secure to a permanent structure portable goals after use.
- Cover goals with protective padding.
- Conduct further research into goal post design.
- Conduct epidemiological studies looking at the mechanism and types of injuries associated with goal posts.

## 6.8 Rules of the Game

Pushing, holding, barging, tripping, striking or intentional kicking are not allowed in soccer and free-kicks are awarded when rules are broken. If a player commits a serious foul, abuses an official or continues to break the rules, then they can be warned with a yellow card, or sent from the field with the presentation of a red card (Ausport, 1997).

- Red cards: abusive language, violent play, committing a foul after being yellow carded.
- Yellow cards: tripping, stalling, arguing.

Keller (1987) reported that studies among Swedish senior players showed that 30% of traumatic injuries were sustained due to foul play. However, it was found to be the player who committed the foul that sustained the more serious injury. Nielsen and Yde (1989) reported similar findings in a prospective study of 123 Danish soccer players, where 25% of injuries were attributed to foul play.

A study conducted by Hawkins and Fuller (1996) investigated the incidence and nature of injuries resulting from fouls during the 1994 World Cup. During the 44 World Cup games analysed, 1272 fouls were committed in the referees' judgement, resulting in an average of 28.9 free kicks per game. Of the medical treatments, 35% resulted from foul play. Of these, 10% of culprits received a free kick, while a free kick was awarded to the victim in 90% of cases. The incidence of injury per player for all injuries was 8.0% and 19.7% as a result of foul play and no foul play, respectively. The major limitation with this study is that it was based on videos of the matches and additional information on players' injuries from extensive media coverage. Limitations of video analysis include the potential for missing incidents out of camera range or on a hidden angle and media reporting can be unreliable.

A questionnaire study by Pilz (1995) investigated the attitudes of 1,207 German soccer players aged 12-14, football coaches and non-playing pupils towards fair play and violence. Results indicated that violence and unfairness were the logical consequence of a sport orientated primarily towards winning. The longer juveniles play soccer in a soccer club, the more they are willing to see intentional fouls as fair.

In order to reduce the number of injuries resulting from foul play, coaches and referees must educate and enforce safe and sportsmanlike behaviour and play.

Three substitutions are allowed to be made any time during the game, as well as one goalkeeper substitution. However, once these players are taken off the field they are not allowed to return to play. This is a problem if all substitutions have been made and a player becomes injured and feels he/she must continue.

The FIFA has published a new, approved, version of the 'Laws of the Game' effective as of July 1997, based on the previous rules, with some minor alterations

### 6.8.1 Recommendations for further research, development and implementation

- Players need to be educated that foul play is not an acceptable part of the game
- The deterrent effect of the send off rule with limited substitution, should be examined in comparison with the benefits of encouraging injured players to leave the field with unlimited substitution
- Rules need to be enforced.

## 6.9 Crowd Control

A major concern to the reputation and popularity of soccer is the worldwide risk of injury and even death through crowd violence. Although Australia has been less prone to this than other countries, signs of tensions in supporting crowds has begun to emerge (Egger, 1990).

Egger (1990) reported that one possible explanation for soccer crowd violence was that the low scoring nature of the game and the high proportion of drawn matches creates a frustration and crowd tension which can boil over into spectator violence. This, however is only one of numerous possible explanations (Shepherd, 1991; Young, 1991; Kerr, 1996).

The FIFA laid down standards for controlling crowd violence in 1989. In 1996, it sent a detailed circular letter to all its associations. In the letter, FIFA reiterated the contents of the resolution and demanded that the following principles be strictly observed (FIFA, 1997):

- Only tickets for the numbered seats are allowed to be sold in stadia (standing room may not be put on sale and must remain empty).

- Crowd capacity must be meticulously verified and never exceeded.
- The method of ticket sales must be arranged in such a way as to rule out forgery.
- Kick off may not take place until the situation outside the terrace and on the terraces is completely under control.
- One or two cordons made up of security forces must be posted outside the stadium (to carry out the first check on spectators and then channel them into the correct area).
- The FIFA commissioner (or, at high risk matches, the FIFA security officer) is required to carry out a systematic check of the safety precautions inside and outside the stadium at every World Cup match. In this connection, every point contained in the security checklist must be checked.
- In the case of stadia with fences separating crowds from the pitch, technical precautions must be taken so that spectators will be able to enter the pitch in emergencies.
- In the case of matches played at night, stadia must be equipped with permanently installed floodlights.

#### 6.9.1 Recommendations for further research, development and implementation

- Ensure that the FIFA regulations are fully enforced

# 7. OVERALL INJURY PREVENTION

## 7.1 Physical Preparation

A participant in sport and physical activity needs to meet at least minimum physical, physiological and psychological requirements to cope with the demands of competition and reduce the risk of injury (Australian Sports Injury Prevention Taskforce, 1997). Individual player factors or intrinsic risk factors, are often related to soccer injuries and can be prevented through corrections in training and conditioning (Larson et al., 1996).

### 7.1.1. Warm-up and stretching

"Warming-up" is a term which covers activities such as light exercise, stretching, and even psychological preparation, before undertaking major sporting activity (Best, 1993). Warm-ups, including stretching, have been recommended as a means of reducing musculoskeletal injury because they improve the range of motion of the joints and improve muscle elasticity, thereby removing some of the physical stresses associated with participating in soccer. Warm-ups are also believed to be beneficial in mental, as well as skill, preparation. Stretching or cooling-down after exercise may be more physiologically effective. This is because there is an increased amount of heat generated in the soft tissues after exercise and this is necessary for the increased elasticity that would enhance stretching (McQuade, 1986). Despite the believed benefits, there is a large debate, as to whether warm-up really is beneficial in preventing injuries in sport. Debate has surrounded the notion, that while warm-up may increase body temperature, it doesn't prevent over-stretching and that it is the psychological preparation that makes a player ready for participation and thus doesn't necessarily prevent injury.

Laboratory studies have demonstrated that the mechanical properties of connective tissues can be altered in response to loading and temperature variations which can bring about changes in joint range of motion (Woo et al., 1990). In reviewing the literature, Best and Garrett (1993) claimed that warm-up prior to exercise, particularly before exhaustive exercise, would help to reduce the incidence and severity of musculoskeletal injuries.

In a one year study, 715 patients with soccer injuries were registered and treated in the emergency department of Randers City Hospital, Denmark. Of the injuries that were reported 9% were classified as resulting from insufficient warm-up (Høy et al., 1992). However, a number of other factors could also be associated.

The Australian Sports Commission, in the document 'The name of the game is Rooball' recommends that children undergo 5-10 minutes of physical warm-up and 10 minutes of skill warm-up prior to any physical activity or game.

It has also been suggested by the Victorian Institute of Sport that 15-20 minutes of warm-up, 8-10 minutes of stretching, with concentration on the lower back, quads, hamstrings, groin, psoas (front of hip) and calves, along with 5-8 minutes of cool down should take place at each soccer activity session (Harcourt, 1995).

### 7.1.2 Training and conditioning

There is little doubt that a major contributor to injury is inappropriately designed training programs, commonly referred to as training errors (Best & Garrett, 1993). Adequate physical fitness is essential prior to participation in sport, as fatigued athletes have decreased skill performances which can lead to injury (Cross, 1993).

With today's sophisticated physiological research and communication, it should be possible for a training program to be designed that is specifically aimed at optimal performance (Cross, 1993). A good training program should include a warm-up and stretching period, gradual increases and variation in training intensity, frequency and duration, drills specific to the sport, a time for cool-down and stretching after exercise and adequate rest and recovery periods (Cross, 1993; Elam, 1986). Effective training programs also need to take into account off-season, pre-season and in-season requirements, to ensure players are not overtrained, overexhausted and maintain optimal physical fitness throughout the season.

Training programs also need to be biologically and chronologically developed. Stanitski (1989) stated that the greatest sources of sports injuries in pre-adolescent and adolescent age groups was as a result of training errors. He suggested that the main reason was that few coaches realised that every child has different capabilities at the same age.

The effect of strength training was monitored by Lehnard et al. (1996). The study recorded injury rate and classification in a men's college soccer team over a 4 year period. During the first 2 years participants were not involved in any strength training regimen. For the following and final two years all participants were placed on a year-round strength training program. The incidence of injury decreased from 15.15 to 7.99 per 1,000 exposures following strength training (Lehnard et al., 1996).

Ekstrand's landmark study (1982), although outside the review period, is important. He implemented seven prophylactic measures, including the correction of training. Overall this program was reported to have resulted in a 75% reduction in injuries. Specifically the correction of training resulted in only 5 strains in the prophylactic program group and 23 strains in the control group. He also found a correlation between team success and the amount of adequate training provided. Teams with more than average training showed a declining number of injuries with increased training. A high practice to game ratio also appeared to be beneficial.

### 7.1.3 Recommendations for further research, development and implementation

Taken together these studies suggest the following areas requiring further attention:

- More research into the role of warm-up, training and conditioning as an injury prevention measure for soccer is needed.
- Controlled research studies should be undertaken into the benefits of different types of warming-up, cooling-down and stretching practices.
- Information about warm-up, cool-down and stretching techniques should be developed and widely promoted to improve specific knowledge of techniques and effectiveness.
- Simple fitness testing should be conducted prior to soccer competition to ensure adequate fitness levels for competition.
- Appropriate education and monitoring of players should be conducted regarding nutritional and hydration demands of soccer, particularly as intensity increases with a training programme, and emphasising complex carbohydrate intake
- Recreational soccer players should not train excessively. If fitness is the overall goal, soccer drills could be interspersed with other activities.
- Soccer players should consider some form of cross-training (eg. bicycling) to improve their fitness levels and remain injury free.
- Soccer skills and fitness should be built-up gradually.
- Soccer players with potential biomechanical abnormalities (eg. leg length discrepancies) should have these assessed by a professional who can recommend corrective actions.
- More research is needed to determine the threshold and optimal levels of the various training factors under which soccer players are likely to remain injury free.
- A campaign aimed at increasing soccer players' awareness of the injury consequences of training errors should be developed and promoted.

## 7.2 Environmental conditions

Traditionally soccer is played on a rectangular field, not more than 68m wide and 105m long with predominantly a grass surface, and less common a surface of sand, gravel or artificial turf. A player covers approximately 10 km of ground per game, of which 8-18% is at the highest individual speed (Inklaar, 1994a) and suffers significant impact forces of two to three times body weight. For this reason the surface and the environmental surrounds are important factors to consider when reviewing the nature and incidence of soccer injuries.

### 7.2.1 Surface

In order to make soccer less dependent on external influences such as weather and to reduce operating and maintenance costs, sand, gravel or asphalt have been used as the playing field. In recent times artificial surfaces have been introduced. The FIFA regulates the field of play in terms of size and markings, but does not make reference to playing surface. Thus it is up to the country, state or organisation to make a decision on the appropriate playing surface, given a variety of influencing factors. The FIFA does however refer to a smooth and level playing field of natural grass in their technical recommendations as well as requirements for the construction or modernisation of football stadia (FIFA, 1996).

The forces transmitted to tissues are changed on different surfaces. Thus, injury frequency and injury pattern in soccer alters due to differing surfaces. Changes in surfaces have had effects on the performance and injury pattern of the sport which were neither expected nor planned (Ekstrand & Nigg, 1989; Nigg & Yeadon, 1987). The same concept has been investigated in relation to footwear in Section 6.4 of this report.

The relationship between soccer injuries and playing surface has been investigated by Berger-Vachon et al. (1986); Engebretsen & Kase (1987); Winterbottom (1985); Ekstrand (1982) and Ekstrand and Nigg (1989).

A controlled prospective study of a male soccer league with 12 teams and 180 players over a three year period was conducted by Ekstrand (1982). Unsatisfactory playing grounds were found to be associated with 24% of the recorded injuries. A combination of poor surface and other factors such as inferior shoes, instability of joints, muscle tightness, or inadequate rehabilitation were the most often cited cause of injury. Rough playing surfaces or slipperiness due to rain, snow or ice was predominantly responsible for traumatic injuries such as contusions, sprains and strains. Overuse injuries such as bursitis, Achilles tendonitis and shin splints were frequently seen during winter training sessions and were related to a combination of inferior shoes and hard playing surface or frequent alteration between different playing surface such as sand, gravel, sawdust and/or wood (Ekstrand & Nigg, 1989).

Engebretsen and Kase (1987) investigated 16 Norwegian teams over a two year period. Injuries on artificial surfaces were reported as occurring at a rate of 30 per 100 hours of game time compared to 20 per 1000 hours on gravel. The incidence of injury on 230 soccer fields during 380,000 playing hours was investigated in a study for the West Berlin Soccer Federation (1985). The injury incidence was 2.6 per 1000 hours on grass, 1.8 on gravel and 0.4 on artificial turf. Fewer injuries when playing on artificial surfaces have also been reported by Winterbottom (1985).

The 1991-1992 National Collegiate Athletic Association (NCAA) soccer report recorded a higher incidence of injury on artificial surfaces than natural surfaces for both women (9.99 vs 7.71/1000) and men (11.45 vs 7.65/1000). Again in the 1994-1995 NCAA season a higher incidence of injury on artificial surfaces was recorded than natural surfaces for both women (17.8 vs 17.5/1000) and men (21.0 vs 20.3/1000).

In contrast, Ekstrand and Nigg (1989) in their review on soccer surfaces, cited a 2-year study on the first artificial soccer surface in Sweden. There was no reported difference in the incidence of injury between artificial, gravel or grass surfaces. The only difference reported was in terms of injury pattern.

The problem with studies, such as those above, that compare grass and artificial surfaces, is that grass itself is a variable surface from country to country, climate to climate and field to field. Ekstrand and Nigg (1989) postulated that there are two main factors involved in surface related injuries: stiffness of a surface or impact absorption qualities and friction between surface and shoe.

The facility where sport occurs impacts on safety. It must be designed to present as little hazard as possible to participants, in addition to providing for maximal performances (Weaver, 1996). It is therefore important to eliminate the possibility of injury occurring due to potholes, sprinkler pop-ups and even the occurrence of rubbish on the field. Fences should be an appropriate height, location and construction, with clearance of at least 6.0m from the touchline and 7.5m from the goal line between the boundary and the fence or wall (FIFA, 1996). Potential obstructions on the playing field should be eliminated where possible. The FIFA provides recommendations in regard to these matters (FIFA, 1996). There is a great deal of responsibility in maintaining the soccer playing surfaces, particularly where the field is used for multiple purposes.

### 7.2.2 Weather

Soccer is generally played in winter, although recent Australian moves have seen a strong summer competition (Ausport, 1997). Therefore extremes in temperature are a frequent association with outdoor soccer. Consequently, the weather becomes a pertinent factor in the risk of injury. Temperature affects bodily function as well as environmental factors, such as playing surface.

No specific evidence of preventive measures in regard to climate-related soccer injuries were identified by this review. Suggestions for injury prevention have been based on general thermo-regualtion recommendations, such as wearing appropriate clothing, using sunscreens, maintaining hydration and by undergoing a process of acclimatisation.

Watering to reduce the hardness of the surface may be an important factor. Given the playing environment it is not possible to promote adequate shade (ie. trees or shade structures). Players should leave the field during severe thunderstorms, to avoid the risk of lightning strike. The FIFA regulations stipulated that a referee is allowed to stop play if: ‘by reason of elements, interference by spectators, or other causes, he deems such stoppage necessary (FIFA, 1984).

### 7.2.3 Recommendations for further research, development and implementation

- Risk management plans to control environmental hazards should be developed, implemented and monitored for facilities.
- More research into the role of environmental conditions such as playing surface and weather conditions should be undertaken in a controlled manner.
- Soccer should not be played under extremes of weather conditions.
- Adequate player hydration should be ensured.
- Soccer players should use a broad spectrum sunscreen in high ultra-violet conditions
- A wet globe bulb temperature system should be available at all soccer matches which are played under hot and humid conditions to assess heat load.
- Risk management plans should incorporate specific regulations regarding the environment.
- Further research needs to be conducted on the interaction between footwear and specific playing surfaces

- Evidence on the effects of interventions between footwear and surfaces should be reviewed with reference to other sports

### 7.3 Modified rules and children

When it comes to sports performance, children must not be thought of as little adults (Stanitski, 1988). Significant differences exist between child and adult athletes, and those interested in injury prevention must understand the difference (Meyers, 1993). Growth and maturation rates even amongst children, demonstrate marked variability along with concomitant gains in coordination and strength, flexibility, and endurance (Stanitski, 1988).

A prospective four year study examining the incidence and nature of injuries in adolescent and preadolescent soccer players was carried out by Kibler (1993). The injury incidence was 2.38/1000 playing hours. Player to player contact, and player to ground contact accounted for 67% of the injuries.

In a similar prospective study, Yde and Nielsen (1990) studied 302 adolescents playing soccer, handball and basketball during one season. The injury incidence rate for soccer was 5.6/1000 playing hours. Forty one percent of soccer injuries occurred during tackles, while 27% occurred during running and 8% while shooting goals. Contact with an opponent was the cause of injury in 35% of cases. Again the majority of injuries were located in the lower extremities (thigh 24%, knee 19%, ankle 27%, foot 19%). One problem in reference to this data was that exposure time could not be calculated exactly as substitutions can be made throughout the game.

A prospective study of injuries encountered during participation in five, one week summer soccer camp for youths aged 6 through 17 years revealed an injury incidence of 10.6/1000 hours for girls and 7.3/1000 for boys (Backous et al., 1988). Again the lower limbs (70%) accounted for the majority of injuries. The limitation of this study, however, was the one week period for which training would be presumed to be intense (22 hours in 4.5 days) given the nature of the camp. Intense training, particularly in youths who are not adjusted has a higher likelihood of resulting in overuse injuries. A further concern is the wide age range of 6-17 years, this 11 year range denotes major physical and psychological changes in ability, skill, development and growth.

During a soccer tournament with participation of 6,600 boys and girls (9-19 years), Schmidt-Olsen et al. (1985), observed injury rates. Of total players, 5.2% were injured. Of these, 51% had ‘slight’, 42% ‘moderate’ and 7% ‘severe injuries’. The incidence of injury was 9.4/1,000 playing hours. However, when ‘slight injuries’ were excluded, the incidence rate dropped. Like other studies involving youth, the incidence was found to increase with age.

A one year retrospective study of 496 male youth soccer players, aged 12 to 18 years from three large soccer clubs in Denmark was conducted by Schmidt-Olsen et al, (1991). The incidence of injury was 3.7 injuries per 1000 hours of soccer played. Seventy percent of injuries were located in the lower extremities, particularly the knee (26%) and ankle (23%). They further proposed that younger players may incur fewer injuries than seniors, because of better flexibility, and less weight and speed during collisions, less aggression and less stress than senior games. The predominance of upper extremity fractures (67% upper and 33% lower extremities) was explained by the fact that younger players are generally not very coordinated when trying to keep their balance, consequently falling and seeking supports from the upper extremities.

As already shown, head and lower extremity injuries in youths are not uncommon. It is important therefore that children and adolescents are taught the correct heading and kicking technique as well as mandatory use of shin guards (Section 6). Greater emphasis needs to be focused on prevention among children as well as adults.

It is for these reasons that the Australian Sports Commission has developed a modified version of soccer called Rooball. Rooball has been developed for primary aged children, to offer them an introduction to the game and a chance to develop skills before progressing to more competitive levels. Rooball is played on a field half the size of a normal field for under tens and a quarter of the size for under 8 year olds. The number of participants, the size of the ball and the duration of the game also vary from the regular soccer game. Six under 8 year olds, play two 15 minute halves with a size 3 ball, while nine under 10 year olds, play two 25 minute halves with a size 4 ball.

These modifications fall within the FIFA 'Laws of the game'. The FIFA regulates that, subject to the agreement of the national association concerned and, provided the principles of these Laws are maintained, the Laws may be modified in their application for players under 16 years of age.

Any or all of the following modifications are permissible:

a) size of the field of play
b) size, weight and material of ball
c) width between the goalposts and height of the cross-bar from the ground
d) the duration of the periods of play
e) number of substitutions

The Australian Soccer Federation in conjunction with the Australian Sports Commission, teachers and education development officers, have produced a lesson plan book for Rooball. This document outlines the correct methods of controlling the ball, heading and shooting for goal and includes a recommended lesson format which incorporates warming-up.

By gradually introducing and developing more formal skills, children's entry skills are far greater when they start to play soccer with standard rules.

Soccer is the largest junior participation sport in Australia (Australian Sports Commission, 1991).

### 7.3.1 Recommendations for further research, development and implementation

- The modified rules version of soccer (Rooball) should be widely implemented
- Children should be encouraged to play with smaller sized balls as in Rooball at all times
- Children and adolescents should be taught correct techniques and procedures.
- The use of shin guards should be enforced.

## 7.4 Education and coaching

Education, as a component of injury prevention should cover a wide range of aspects such as facilities, training and treatment (Damoiseaux & Kok, 1993). The overwhelming majority of experts interviewed by Egger (1990) rated education, particularly of coaches and trainers, as having a major role in contributing to injury prevention. Egger (1990) estimated that $100 million could be saved over three years, for an investment of $300,000 towards education of sports coaches and trainers.

Those in coaching positions need to be fully educated about the correct techniques of training and first aid. It is important that coaches undertake regular updates in injury prevention, first aid, basic life support and rehabilitation principles (Weaver et al., 1996) Coaches of soccer teams who are accredited, need to have this qualification reviewed every four years. As soccer is developing in terms of preventing injury, coaches need to be aware of the current status of knowledge. This may mean disregarding old coaching manuals or beliefs, for new ones, for the benefit of the soccer player and the game.

The Australian Soccer Federation, through its National Coaching Scheme, runs coaches' courses in four levels. The level 0 is part of the Aussie Sport Coaching Program and is a six hour introductory course. Level 1, 2 and 3 courses then increase in detail.

Instruction clinics on proper soccer techniques currently occur in school-related organisations. Guidelines have been produced by the Australian Sports Commission and the Australian Soccer Federation to aid in school education programs, particularly on Rooball and progression to traditional soccer.

### 7.4.1 Recommendations for further research, development and implementation

- All coaches should be accredited and undergo regular re-accreditation.
- Coach education schemes should be updated regularly to ensure they provide current information.
- Instruction clinics for the wider community should be developed and made available widely.
- Education resources for informal soccer need to be developed and disseminated.
- Schools should seek advice from the Aussie Sports Program in terms of modified rules, as well as the state organisation for guidance on program development.

## 7.5 First aid and rehabilitation

Injuries need to be properly managed to restrict the possibility of further damage. Overall, the treatment goals are pain relief, promotion of healing, decreased inflammation, and a return to functional and sports activities as soon as possible.

A previously sustained injury is consistently reported as a strong predictor of another injury occurring. In other words, many injuries are re-injuries or aggravation of a pre-existing injury.

According to Powell et al. (1986), a previous injury may be more likely to re-occur because the original tissue, or the injury may not have healed completely. This leads to the conclusion that complete and controlled rehabilitation of an injury needs to be achieved, and sensible preventive precautions taken, before the person begins to play soccer again.

This procedure may involve, first aid, taping or bracing, referral and general rehabilitation. However, the causes of soccer injuries are so multifactorial and diverse that any specific single measure proposed would probably be of help to only a small minority of players. It is likely, therefore, that a combination of procedures may need to be administered to prevent recurrence.

### 7.5.1 Sports first aid

Rest, ice, compression, elevation and referral (RICER), is a well known procedure to initially manage a soccer injury and thus restrict the possibility of further damage (Knight, 1985; Larkins, 1990). While this procedure is well recognised and widely used, studies indicating the benefits of the procedure, conducted within the last ten years, have been minimal. Nevertheless, it is so widely used and promoted as good first aid practice, that its effectiveness is generally accepted.

Sports Medicine Australian (SMA) in its 'Sports First Aid Course' provides guidance on the RICER technique (National Sports Trainers Scheme, 1994). SMA identifies the benefits to be a reduction in: the severity of further injury; haematoma and swelling; the amount of tissue damage; and finally a reduction in recovery time (National Sports Trainers Scheme, 1994).

One of the major issues in the management of both acute and traumatic injury and overuse injury is correct diagnosis (Fallon, 1997). Thus injured players should seek immediate treatment on the field by a qualified coach, trainer or medical personnel, followed up by consultation with a sports physician, orthopaedic surgeon, general medical practitioner, physiotherapist etc.

A further point relates to the time of presentation of overuse injuries. Anecdotal evidence suggests that the prognosis of overuse injuries is related to early presentation and this is based on the fact that an acute or sub acute inflammatory process is far easier to treat than a chronic degenerative process in which evidence of inflammation is often lacking (Fallon, 1997). Therefore players should be educated to present within a week of the onset of injuries which do not have an obvious traumatic precipitating event (Fallon, 1997).

### 7.5.2 Taping and bracing

It is generally believed that taping and bracing of a joint helps to reduce the range of movement possible at that joint and therefore helps to reduce the risk or severity of injury (National Sports Trainers Scheme, 1994). However, debate continues in the scientific literature. Evidence for the effectiveness of ankle taping and bracing to prevent re-injury is quite strong. It is less clear whether these measures prevent new injuries. There is not yet good evidence on the effectiveness of taping or bracing the knee joint for soccer.

#### *7.5.2.1 Ankle*

An injury prevention program, which consisted of several measures including ankle taping was conducted by Ekstrand (1982) on 180 male senior soccer player over three years. All players with previous ankle sprains and/or clinical instability had their ankles taped prophylactically. In the test group none of the 52 ankles that were prophylactically taped sustained a strain, whereas 9 of 11 ankle injuries in the control group occurred among players with a past history of ankle sprain and/or clinical instability ($p<0.05$).

The effect of ankle support was investigated by Karlsson and Anderson (1992) in 20 athletes with chronic lateral ankle joint instability. The results from this study suggested that taping was a beneficial measure for reducing the rate of injury, particularly re-injury. The greatest stability was obtained in ankles with the highest degree of mechanical instability before being taped.

After exercise, however, the ankle tapes were generally loose, affording only limited protection (Karlsson & Anderson, 1992). Thus although laboratory studies have indicated that prophylactic taping effectively restricts excessive ankle inversion before exercise, most recent studies indicate that this restriction is lost after an exercise bout. Taping for every match or practice is also expensive and requires the assistance of an experienced person to apply the tape.

In contrast, the application of a semirigid orthosis is less expensive in the long term, and can be applied by the soccer player with ease and without assistance. The evidence from laboratory studies also indicated that most commercially available semirigid orthoses effectively restrict inversion of the ankle before and after a bout of exercise (Alves et al., 1992; Greenie & Hillman, 1990; Gross et al., 1991; Kimura et al., 1987; Surve et al., 1994).

A study by Surve et al. (1994) evaluated the effect of a semi-rigid ankle orthosis (Sport-Stirrup) on the incidence of ankle sprains in soccer players during 1 playing season. Senior soccer players were divided into two groups those with a history of ankle sprain (258) and those without (246) and then randomly allocated to the semi-rigid orthosis (144) or control group (160). There was a significant reduction in the incidence of ankle sprains per 1000 playing hours by those with a previous history using the orthosis (0.14/1000hrs) compared to those not using the orthosis with a previous ankle sprain history (0.86/1000hrs). The incidence of ankle sprain was significantly higher in the non-braced, previous sprained group (0.86/1000hrs) compared to the non-braced group without a previous history (0.46/1000hrs). Thus Surve et al. (1994) concluded that a semirigid orthosis significantly reduced the incidence of recurrent ankle sprains in soccer players with a previous history of ankle injuries.

A comparison study between the use of orthosis and coordination training was conducted by Tropp et al. (1985). Four hundred and fifty senior soccer players in the Swedish national league division VI were divided into three groups (control, training, orthosis). A previous history of ankle injury was recorded in 48% of all participants. Of all those in each group, 25% of controls, 3% of the orthosis group and 5% of the training group received ankle sprains. Of those with a previous history of ankle sprain, 25% of the controls, 2% of the orthosis group and 5% of the training group received ankle injuries. The investigators concluded that orthotics and training were beneficial in reducing ankle injuries.

#### *7.5.2.2 Knee*

Baker (1990) suggested that prophylactic bracing not only does not offer much protection for knee joint ligaments but in fact may be the cause of additional injuries in that area. Strapping and bracing can effectively stabilise joints such as the thumb, elbow and ankle as these joints can normally tolerate small losses in movement without affecting function. On the other hand, they are usually ineffective measures in stabilising the knees and the shoulder for the rigours of competitive sport and limiting the function of these joints, even if assisting with proprioceptive control (knowledge of where body part is without looking).

A biomechanical evaluation of taping and bracing on the knee joint translation and rotation was conducted on five randomly selected cadaver specimens (Anderson et al., 1992). This study found that taping and bracing together produced the greatest reduction in both anterior-posterior translation and internal-external rotation, providing objective evidence of the restraining capabilities of these protective systems that may prove to be beneficial in the clinical setting. However, load levels used to test the knee laxity (weakness of supporting structures of the knee) were much lower than those levels anticipated based on in vivo experience. Furthermore, there was a lack of active muscle tension in the cadaveric model. Under normal conditions, the tension produced by muscles across the joint would be expected to decrease the displacement at a given load. The final limitation of this study was in regard to the loosening and slippage of the tape or brace. This is a common problem encountered during activity, which can decrease effectiveness. This situation was not tested and the results may therefore be overly optimistic when considering their actual clinical effectiveness.

Research specifically focusing on the repetitive actions of acceleration, deceleration, jumping, pivoting, turning and kicking of the ball needs to be conducted in soccer players to establish the long term benefits of taping and bracing in a practical setting.

### 7.5.3 Rehabilitation

Returning to play too early after injury can make the player susceptible to further injury. The coach should ensure that the risk of further injury is reduced. Concentration on muscle stretching exercise routines before play will assist in preventing injury.

A rehabilitation programme cannot be regarded as having been completed until the athlete is free from pain; muscle strength has returned to about the pre-injury level; and articulatory mobility (joint union movement) has recovered to the pre-injury level.

In reviewing the literature only one study into the effects of rehabilitation programmes with respect to soccer could be identified. Ekstrand (1982) demonstrated that a whole package of measures including ‘controlled rehabilitation’ could reduce the number of sports injuries in soccer. The specially devised rehabilitation program gradually increased the stress on the injured leg and step by step adapted the player to return to play. Return to play was determined by a doctor and physiotherapist, and a full, painfree range of motion and regain of 90% of muscle strength was mandatory. Of those undergoing controlled rehabilitation no injuries were recorded compared to the control group in which 13 injuries were reported.

### 7.5.4 Recommendations for further research, development and implementation

Taken together these studies suggest some areas requiring further attention:

- Controlled research is needed to determine the effectiveness of taping and bracing of ankle and knee joints in the primary presentation of injury
- Taping or bracing should be considered by professionals in the prevention of re-injury of ankle joints
- Return to play after injury should only occur after full recovery
- Qualified first aid personnel should be available at all sporting events.
- Conduct research into the biomechanics of acceleration, deceleration, jumping, cutting, pivoting, turning, heading and kicking of the ball.
- Ensure that all players have prompt and adequate first aid treatment.
- Players should undergo controlled rehabilitation before returning to play after an injury.

# 8. INDOOR SOCCER/FUTSAL

Indoor soccer, commonly referred to as futsal, began in 1930 with a five-a-side version of soccer for youth competition in the YMCA. It was not until 1984 that it was formally introduced in Australia, but was quickly adopted by all states and territories (Australian Sports Commission, 1991). The term futsal is the international term for the game, derived from the Spanish or Portuguese word for “soccer”, **fut**bal or **fut**ebol, and the French or Spanish word for “indoor”, **sal**on or **sal**a. Futsal is currently played by over 100 countries with 12 million players. Futsal is the only official form of indoor soccer approved under the auspices of the FIFA.

While the strategy is the same in both indoor and outdoor soccer, the confined area demands quick reflexes, fast thinking, and pin-point passing (USFF, 1997). The game is played on a basketball sized court and a variety of surfaces can be used. The ball is made of leather and especially designed for the game, with both senior and junior models. Unlike traditional outdoor soccer, an unlimited number of substitutions may be made and can be taken when the ball is out of play or the referee stops the game. Futsal, also has cards for disciplinary fouls. Firstly a yellow card to caution, secondly a blue card meaning dismissal from the game, but the player can be substituted, whilst a red card means dismissal from the game with no substitution (Australian Sports Commission, 1991).

There is a limited amount of epidemiological data for indoor soccer injuries. The incidence of indoor soccer injuries occurring over a 7 week period at a local indoor soccer arena was documented by Lindenfeld et al. (1994). The overall injury rates for males and females were similar, 5.04 and 5.03 per 100 playing hours, respectively. Collision with another player was the most common mechanism of injury, accounting for 31% of all injuries, while a player was kicked by a opponent in 16% of all cases. The most common injury types were reported to be sprains and strains. Injuries to the knees and ankle both accounted for 23% of total injuries, while 12.5% were to the head. Goalkeepers had injury rates (4.2/100hrs) similar to non-goalkeeper positions (4.5/100hrs).

A comparison of injuries among indoor and outdoor youth players revealed that the incidence of injury for indoor players was 4.5 times that of outdoor players when calculated per 100 hours of team play, and 6.1 times greater when calculated per 100 hours of player game participation (Hoff & Martin, 1986). Medical assistance was required by 24.3% and 6.5% or indoor and outdoor injured players, respectively. Collision between players, resulted in injuries to 60.9% of outdoor players and 70.3% of indoor players. A number of methodological issues may have influenced the results of this study. Injury data was self reported retrospectively at the end of the season and the response rate was only 63%. Biases associated with self selection and recall and the lack of validation must be considered.

In contrast a prospective study on the incidence of indoor soccer was conducted by Putukian et al. (1996). This study looked at 844 competitive men and women involved in an indoor soccer tournament. The overall injury rate per 100 player hours was 4.44. Ankle sprains were the most common injury, while 71.4% of injuries occurred to the lower extremities.

Indoor soccer accounted for 14% of all soccer injuries presenting to emergency departments in Victoria, Australia (Routley & Valuri, 1993). Players were reported to be three times more likely to sustain an ankle sprain in indoor rather than outdoor soccer. Consequently more lower limb injuries were reported in indoor soccer compared to outdoor soccer. As discussed earlier, a limitation of this data is that it is based on just one source of data from a particular place of treatment (Finch et al., 1995).

Wrist injuries in indoor soccer were reported to be more common as the players use outstretched arms to decelerate into corners and from being slammed into the side boards.

Overall these studies tend to support the notion that the incidence of injury is higher in indoor than outdoor soccer. The logical explanation for this is the smaller field, confining walls and intensity of play due to the short playing shifts and time penalties (Hoff & Martin, 1986).

### 8.1.1 Recommendations for further research, development and implementation

- Well designed studies are required to determine the relative risk of injury between indoor and outdoor soccer.
- Epidemiological studies in terms of the mechanism of injury and the relation to the games surrounds needs to be conducted.
- Risk management plans should be prepared, implemented and monitored based on the apparent risk of futsal.

# 9. SUMMARY AND CONCLUSIONS

This report has discussed hospital emergency department data and the full range of injury prevention activities for preventing soccer injuries. Recommendations for further countermeasure research, development and implementation have been based on the review presented here as well as discussions with experts acknowledged in this report.

Many of the recommended countermeasures have yet to be proven to be effective and more attention to controlled studies “in the field” are needed. More effort directed to basic scientific studies to better understand the biomechanics of soccer, the mechanisms of injury and the role of various risk factors in causation is also required. Indeed, the evidence for the effectiveness of certain countermeasures such as warming-up, shoe design, taping and bracing remains equivocal.

In addition to the specific recommendations in this report, the following set of more general recommendations can be made:

- Improved data collection about the occurrence of soccer injuries and their associated factors needs to be developed, maintained and analysed.
- Data about injuries and their associated factors in recreational soccer needs to be collected.
- Data collections should conform to guidelines for sports injury surveillance being developed and promoted nationally.
- Information about preventing soccer injuries should be disseminated widely through soccer broadcasts, soccer equipment points of sale, soccer magazines and more general magazines, and media outlets .
- Guidelines for minimum safety requirements for soccer events (including the need for mobile phones, telephone contacts, first aid kits, etc) should be developed and widely disseminated.
- Future research studies to determine risk factors or to evaluate the effectiveness of countermeasures need to be controlled and conducted in the field.
- Risk management plans for sporting bodies, clubs and associations should be developed, implemented, enforced and regularly reviewed.
- Risk management plans for facilities should be developed and implemented.

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## APPENDIX 1: Frequency of adult injury by injury type

| **Author** | **Finch et al., 1995** | **Engström, 1991** | **Lüthje, 1996** | **Kujala, 1995** | **Cunningham & Cunningham 1996** | **Ekstrand, 1982** | **Nielsen, 1989** | **Inklaar et al., 1988** | **Poulsen et al., 1991** | **Aglietti et al., 199** | **Hoy et al., 1992** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **data source** | Australian emergency department presentations | Prospective Elite females | Prospective study of professional players in Finland | National sports injury insurance registry data (Finland) | Medical coverage 1994 Aust. Uni. Games | Senior amateur males | Danish soccer clubs of various levels | 2 x Dutch non-professional soccer clubs. Various level | Male tournament prospective | Professional Italian soccer players | Prospective |
| **n** | 4626 | 41 (78 injuries) | 236 (170 injuries) | 26330 (all ages) | 5106 | 180 | 89 (109 injuries) | 477 | 150 (248 injuries) | 1018 athletes (all ages) | |
| **Period** | 1989-1993 | 1 year | 2 seasons | 1987-1991 | 6 days | 29 | 1 season | 0.5 season | 1 season | 11 years | |
| **Injury %** | | | | | | | | | | | |
| **sprain** | 37.1 (strains) | 33.0 | 36.0 (strains) | 56.1 (strains) | 24.0 | 18.0 | 48.6 | 30.0 | 42.1 | 24.0 | 45.0 |
| **strain** | | 10.0 | | | 16.0 | 20.0 | 21.1 | 17.5 | 29.8 | 15.5 | |
| **contusion** | 15.2 | 15.0 | | | 23.0 | 2.0 | 9.2 | 25.0 | 12.1 | 23.3 | 25.0 |
| **dislocation/ subluxation** | 3.0 | 3.0 | 1.6 | 0.8 | | 4.0 | | 2.5 | | | 2.0 |
| **inflammation** | 11.2 | | | | | | | | | | |
| **fracture** | 20.8 | 1.0 | 6.9 | 9.6 | | | 5.5 | 17.5 | 7.0 | 7.0 | 18.0 |
| **wound** | 8.7 | | 32.2 | 31.1 (bruises) | 15.0 | | | | 3.5 | 15.5 | 5.0 |
| **bursitis/ tendinitis** | | 24.0 | | | | | 15.5 | 15.0 | | | |
| **concussion** | | | 0.3 | | | 4.0 | | | | 2.3 | |
| **other** | 3.8 | 13.0 | 17.4 | 2.5 | 22.0 | | | | 5.3 | 12.3 | 5.0 |
| **overuse** | | | 5.7 | | | 23.0 | | | | | |
| TOTAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## APPENDIX 2: Frequency of youth injury by injury type

| Author | Backous et al., 1988 | Routley, 1991 | Maehlum et al., 1986 | Schmidt-Olsen et al., 1985 | Hoff & Martin, 1986 | Kibler, 1993 |
|---|---|---|---|---|---|---|
| **data source** | Soccer summer camp Prospective | Victorian emergency department presentations | prospective six day international tournament | Prospective and retrospective | Outdoor and indoor retrospective | Medical coverage prospective |
| **n** | 1139 (216 injuries) | 388 | 1348 (411 injuries) | 496 males | 120 injuries | 179 injuries |
| **period** | 5x1week camps | 1989-1990 | 6 days | 1 year | 1 outdoor season. 1 indoor season | 4 years |
| **injury %** | | | | | | |
| **sprain** | 16.3 | 24.0 (strains) | 21.7 | 20.2 | 23.9/23.0 | 21.8 |
| **strain** | 28.4 | | | 9.8 | | 24.5 |
| **contusion** | 31.9 | | 47.0 | 32.9 | 34.8/40.5 | 32.0 |
| **dislocation /subluxation** | | | 1.0 | 1.1 | 17.4/18.9 | |
| **fracture** | | 32.0(dislocations) | 5.6 | 4.0 | -/1.4 | 9.0 |
| **wound** | 1.9 | 31.0 (bruises) | 18.0 | 24.2 | 2.2/8.1 | |
| **bursitis/tendinitis** | | | | 5.2 | | |
| **concussion** | | 2.0 | | 1.2 | | 1.5 |
| **other** | 21.7 | 11.0 | 6.8 | 1.4 | 21.8/8.1 | 11.2 |
| **TOTAL** | 100 | 100 | 100 | 100 | 100 | 100 |

** Overall statistics presented in the epidemiology section of this report do not include indoor incidences of Hoff & Martin 1986*

## APPENDIX 3: Frequency of adult injury by body part (%)

| **Author** | **Finch et al., 1995** | **Routley and Valuri, 1993** | **Engström, 1991** | **Lüthje, 1996** | **Kujala, 1995** | **Ekstrand, 1982** |
|---|---|---|---|---|---|---|
| **data source** | Australian emergency department presentations | Victorian emergency department presentations | Prospective<br>Elite females | Prospective study of professional players in Finland | National sports injury insurance registry data (Finland) | Senior amateur males |
| **n** | 4626 | 630 | 41 (78 injuries) | 236 (170 injuries) | 26330 (all ages) | 180 |
| **Period** | 1989-1993 | 1991-1993 | 1 year | 2 seasons | 1987-1991 | 1 season |
| **Injury %** | | | | | | |
| **head/face** | 11.6 | 11.0 | 4 (head, spine, trunk) | 9 (head, neck, face) | 4.9 (head, neck) | |
| **upper extremities** | **21.5** | **24.0** | | **6**.0 | **12.1** | |
| **arm** | | 15.0 | | | | |
| **hand/finger** | | 9.0 | | | | |
| **lower extremities** | **58.9** | **58.0** | **88**.0 | **76**.0 | | |
| **leg** | | | | | 6.5 | |
| **foot** | | 10..0 | 9.0 | | 7.7 | 12.0 |
| **knee** | | 13.0 | 23.0 | | 21.5 | 20.0 |
| **lower leg** | | 10.0 | 9.0 | | | 12.0 |
| **ankle** | | 22.0 | 26.0 | | 20.5 | 17.0 |
| **upper leg** | | 3.0 | 15.0 | | | |
| **thigh** | | | | | 10.6 | 14.0 |
| **groin** | | | 6.0 | | | 13.0 |
| **back** | | | | | | 5.0 |
| **trunk** | 4.9 | 5.0 | | 9.0 | 10.9 | |
| **other** | 3.1 | 2.0 | 8.0 | | 5.3 | 7.0 |
| TOTAL | 100 | 100 | 100 | 100 | 100 | 100 |

## APPENDIX 3 (continued)

| **Author** | **Nielsen, 1989** | **Inklaar et al., 1998** | **Ekstrand, 1991** | **Poulsen et al., 1991** | **Brynhildsen et al., 1990** | **Aglietti et al., 199** |
|---|---|---|---|---|---|---|
| **data source** | Danish soccer clubs of various levels | Dutch male non-professionals | Male senior soccer division<br>prospective | Male tournament<br>prospective | retrospective<br>Senior females | Professional Italian soccer players |
| **n** | 89 (109 injuries) | 245 | 256 | 55 (57 injuries) | 150 (248 injuries) | 1018 athletes (all ages) |
| **Period** | 1 season | 4 months | 1 year | 1 season | | 11 years |
| **Injury %** | | | | | | |
| **head/face** | | | | | 4.8 | 13.0 |
| **upper extremities** | | | | | **5.6** | **17**.0 |
| **arm** | | | | | | |
| **hand/finger** | | | | | | |
| **lower extremities** | **84.4** | **70.0** | **88**.0 | **93**.0 | **86.8** | **67**.0 |
| **leg** | | | 12.0 | | | |
| **foot** | 8.3 | | 12.0 | 21.0 | 3.6 | |
| **knee** | 18.3 | 17.5 | 20.0 | 23.0 | 20.1 | |
| **lower leg** | | 7.5 | | 2.0 | 14.0 | |
| **ankle** | 35.8 | 27.5 | 17.0 | 19.0 | 39.5 | |
| **upper leg** | | 17.5 | | | 6.0 | |
| **thigh** | 22.0 | | 14.0 | 18.0 | | |
| **groin** | | | 13.0 | 10.0 | 3.6 (hip) | |
| **back** | | | 5.0 | | | |
| **trunk** | | | | | | 3.0 |
| **other** | 15.6 | 30.0 | 7.0 | 7.0 | 2.8 | |
| TOTAL | 100 | 100 | 100 | 100 | 100 | 100 |

## APPENDIX 4: Frequency of youth injury by body part

| **Author** | **Backous et al., 1988** | **Finch et al., 1995** | **Routley, 1991** | **Maehlum et al., 1986** | **Schmidt-Olsen et al., 1985** | **Yde & Nielsen, 1990** | **Hoff & Martin, 1986** | **Kibler, 1993** | **Inklaar, 1996** |
|---|---|---|---|---|---|---|---|---|---|
| **data source** | Soccer summer camp Prospective | Australian emergency department presentations | Victorian emergency department presentations | prospective international tournament | Prospective and retrospective | Prospective youth soccer teams | Indoor and outdoor retrospective | Medical coverage prospective | Dutch male non professionals |
| **n** | 1139 (216 injuries) | 3630 | 388 | 1348 (411 injuries) | 6600 | 152 | 120 injuries | 179 injuries | 232 |
| **period** | 5x1 weeks | 1989-1993 | 1991-1993 | 6 days | 1 year | 1 season | 1 outdoor/1 indoor season | 4 years | 4 months |
| **Injury %** | | | | | | | | | |
| **head/face** | 6.9 | 12.7 | 14.0 | 24.8 (spine, trunk) | 4.3 (face) | | 13.3 | 8 (neck) | |
| **upper extremities** | **4.7** | **43.4** | **41**.0 | **14.1** | **10.3** | **4**.0 | **14.2** | | |
| **arm** | 1.9 | | | | | | | | |
| **hand/finger** | 2.8 | | | | | | | | |
| **lower extremities** | **65.8** | **39.1** | **22**.0 | **61.1** | **67.4** | **89**.0 | **60.0** | **73.5** | |
| **leg** | 23.9 | | | | | 24.0 (leg, thigh) | | | |
| **foot** | 10.2 | | 23.0 | | 0.3 | 19.0 | | 12.8 | |
| **knee** | 12.6 | | | | 26.0 | 19.0 | | 15.8 | 25.6 |
| **lower leg** | | | | | 10.9 | | | | 16.3 |
| **ankle** | 19.1 | | | | 23.1 | 27.0 | | 13.0 | 18.6 |
| **upper leg** | | | | | | | | | 25.6 |
| **thigh** | | | | | | | | 21.0 | |
| **groin** | 2.8 | | | | 7.1 | | | | |
| **back** | 2.8 | | | | 13.8 | | | | |
| **trunk** | | 3.1 | | | | | 12.5 | 10.9 | |
| **other** | 17.1 | 1.6 | | | 4.2 | 7.0 | | 18.5 | 14 |
| TOTAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

** Overall statistics presented in the epidemiology section of this report do not include indoor incidences of Hoff & Martin 1986*

## APPENDIX 5: Incidence of injury rates per 1,000 hours of practice or game

| **Author** | **Engström, 1991** | **Engström, 1990** | **Lüthje, 1996** | **Ekstrand, 1982** | **Nielsen, 1989** | **Poulsen et al., 1991** | **Brynhildsen et al., 1990** | **Yde & Nielsen, 1990** | **Backx et al., 1991** |
|---|---|---|---|---|---|---|---|---|---|
| **data source** | Prospective<br>Elite females | Semi-professional males Prospective | Prospective study of professional players in Finland | Senior amateur males | Danish male soccer clubs of various levels | Male tournament prospective<br>high/low skilled | retrospective<br>female | Prospective<br>Children | Prospective<br>Children self reporting |
| **n** | 41 (78 injuries) | 64 (85 injuries) | 236 (170 injuries) | 180 | 89 (109 injuries) | 150 (248 injuries) | 2072 | 152 (62 injuries) | 361 |
| **Period** | 1 year | 1 season | 2 seasons | 1 season | 1 season | 1 season | | 9.9 | 8 |
| Game | 24.0 | 13.0 | 2.3 | 16.9 | 14.3 | 19.76/20.69 | 6.5 | 1.7 | 1.6 |
| Practice | 7.0 | 3.0 | 1.8 | 7.6 | 3.6 | 4.07/5.69 | 2.1 | | |