# THE EPIDEMIOLOGY OF INJURY AND RISK FACTORS ASSOCIATED WITH INJURY IN FIRST LEAGUE FIELD HOCKEY PLAYERS

Thesis submitted in partial fulfilment of the degree of Master of Philosophy

(Sports Physiotherapy)

by

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## TABLE OF CONTENTS

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## DECLARATION

I, Kerry Jean Ferguson, do hereby declare that this dissertation embodies only my original work except where acknowledgement indicates otherwise and that no part of it has been, or is being, submitted for a degree at this or any other university.

This thesis is presented in partial fulfilment of the requirements for the degree of MPhil (Sports Physiotherapy).

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# ABSTRACT

This study investigated the epidemiology of injury in a population of first league field hockey players during a playing season, establishing the true incidence (injuries/1000 hours) of injury, as well as the risk factors associated with field hockey injuries. Both the epidemiology of field hockey injuries, and associated risk factors, have not been well investigated on an international level, and no data on Southern African players have been published.

A study population of 222 first league hockey players (males n=111, females n=111) from one particular region were followed over the duration of a hockey season (7 months). A pre-season player profile questionnaire established player characteristics and training methods. A pre-season fitness assessment recorded the flexibility (sit and reach test), muscle power (standing broad jump), speed (40 m sprint) and endurance capacities (double winder) of all the players. Male players performed significantly better in the muscle power ($p=0.0001$), speed ($p=0.0001$) and muscle endurance ($p=0.0001$) tests compared to female players. However, female players recorded significantly better flexibility results ($p=0.012$) compared with male players. Player position influenced the results of the pre-season fitness assessment. Attacking players (strikers, midfielders) achieved significantly better results in the muscle power ($p=0.0704$), speed ($p=0.0003$) and muscle endurance ($p=0.002$) tests compared with defending players (defenders, goalkeepers).

During the prospective study, an injury report form was completed for players that sustained injuries during the season. An injury was defined as physical damage that resulted in (i) a player being unable to complete the match or practise, (ii) a player missing a subsequent match or practise, or (iii) a player requiring medical attention.

An overall incidence of injury of 10/1000 hours was reported for the playing population, with an injury risk of 0.59 injuries per player per season. No other study of hockey injuries have recorded the true incidence of injury.

A number of factors were associated with field hockey injuries. The incidence of injury was significantly greater in matches compared to practices (p=0.003). The highest incidence of injury was recorded in the beginning of the season (month 2)(16 injuries/1000 hrs).

Strikers reported the highest incidence of injury (11/1000 hrs). In certain instances the player position could be associated with an injury to a specific anatomical area or mechanism of injury. For example, goalkeepers sustained significantly more upper limb injuries than players in outfield positions (p=0.001), which can be attributed to the nature of their play. The activities of a goalkeeper include diving, and fending off the ball with their hands.

The most frequently injured anatomical areas were similar to those reported in other studies of field hockey injuries, namely the fingers (1.6/1000 hrs), knee (1.4/1000 hrs) and ankle (1.4/1000 hrs) joints, and hamstring muscle (0.8/1000 hrs). The type of injuries sustained were predominantly muscle strains (2.4/1000 hrs), ligament sprains (2/1000 hrs) and fractures (1.7/1000 hrs). The most frequent mechanism of injury was tackling (2.3/1000 hrs). There was a significantly higher incidence of injury reported on artificial turf (13/1000 hrs) compared with grass (4/1000 hrs)(p=0.015). Players who discontinued hockey due to injury missed an average of four subsequent matches or practices.

There was no significant association between past injury history, pre-season training, stretching methods, equipment usage and pre-season fitness assessments and the incidence or epidemiology of injury in hockey players.

## List of Tables

## List of Figures

# Chapter One

# INTRODUCTION AND SCOPE OF THE STUDY

Field hockey is a sport with a long history and its' origins as a semi-organised activity can be traced back to Asia in approximately 2000 BC. The Egyptians and Greeks played an early form of the game, and it was the Romans that developed it further and introduced it to the European nations that they conquered. It was on this basis that the French, German and Dutch versions of the game were developed. At one stage the game attained such popularity in England that it was banned by King Edward III in 1365, because of it's interference with mens' national service (Reilly 1992).

The first set of rules for the game of hockey were drafted upon the formation of the Blackheath club in London in 1840. The rules of the game were standardized in 1883, and it became an Olympic sport in 1908. At present the game is regulated by the International Hockey Federation (Reilly 1992).

In the past decade, field hockey has undergone rapid change. The rules have been altered so that the game continues without interruption for longer periods of time and all international matches, as well as all first league matches in South Africa, are played on artificial surfaces. Playing on an artificial surface has altered the technical, tactical and physiological requirements of the game (Reilly 1992). An increase in the physical demands of the sport has potentially increased the risk of injury and therefore the prevention of injury has become of greater importance.

However, very few well conducted scientific studies have documented the incidence and nature of injuries sustained during a season of field hockey. In particular, no studies have been conducted on South African players.

Individual sports cultures and habits differ from country to country, and therefore local epidemiological studies are important to determine injury risk in players in a particular country.

A single epidemiological study on field hockey injuries in the United States of America over the duration of four seasons has been reported (Rose 1981). In this study the womens' California State University hockey team was monitored from 1976 to 1979. A total of 81 injuries were recorded, with the ankle being the most frequently reported site of injury. This research is of limited scientific worth, as the true incidence of injury and playing hours were not recorded. A further limitation of the study was that it monitored only a small sample, a single team, which was only representative of a single gender and level of play.

Prospective studies of hockey injuries during tournaments have been reported (Jamison and Lee 1989). However, it can be expected that the type and severity of injury incurred during a tournament may differ from injury patterns reported during a playing season. Specific reasons for this observation will be discussed in the literature review chapter of this thesis.

Several retrospective studies have reported hockey injuries in isolated anatomical areas, namely facial injuries, dental injuries and lower back pain. These reports of specific isolated injuries provide some information on the prevalence of a particular injury within a hockey playing population (Bolhuis 1986, Bolhuis 1987, Cannon and James 1984). Correlational studies and case series have been conducted with reference to a specific area of injury.

With the exception of one prospective study on lower leg injuries in schoolgirl players (Petrick 1993), the remaining research has focussed on low back pain in hockey players (Reilly and Seaton 1990, Fenety and Kumar 1992).

None of the studies on field hockey injuries have expressed the true incidence of injury (number of injuries per exposure hours). Injuries per exposure hour is the only method of accurately comparing injury risk from one study to another, as well as among different sports. For instance, it will allow comparison of injury risk between sports such as hockey and rugby. At present rugby is perceived as having a higher incidence of injury than hockey.

The anthropometric and physiological characteristics of hockey players have been reported. These parameters include measures of overall fitness, fitness relative to playing position and morphological data (Verma et al 1979, Bhanot and Sidhu 1983, Ready and van der Merwe 1986, Reilly and Bretherton 1986, Scott 1991). None of these studies related their findings to the injuries sustained by field hockey players.

Information generated in an epidemiological study can be used to evaluate strategies to prevent injury and allow for identification of new injury patterns. These studies document the magnitude of an injury problem, identify high risk groups for injury and new hypotheses of injury risk factors can be generated. Such knowledge would enable preventative measures to be implemented.

The study reported in this thesis is a prospective epidemiological study to determine the true incidence of hockey injuries over the duration of one full playing season, as well as identifying risk factors associated with field hockey injuries.

Ten male and ten female teams were monitored whilst competing in the first league in the Western Cape for the duration of the 1995 season. This study differs from previous research into hockey injuries in that it includes both male and female players and was conducted over the duration of an entire playing season.

Part one of the study was conducted in the weeks preceding the start of the playing season. The sample population underwent a fitness test to ascertain pre-season fitness, and completed a questionnaire which was used to formulate a player profile.

Part two of the study dealt with the documentation of injuries that were sustained during the playing season. The incidence of injury with respect to gender, age, playing position, time of season, phase of play, mechanism of injury, site and type of injury and the severity thereof were documented. The influence of the playing surface on injury was also recorded.

# Chapter Two

# LITERATURE REVIEW

## A review of the epidemiology of field hockey injuries and the risk factors associated with these injuries

**Contents**

## 2.1 Introduction

Epidemiology is the study of the distribution and determinants of disease (data) frequency in groups of persons (Kramer 1988). Data collected in an epidemiological study are used to provide clues to the aetiology of injury (Kramer 1988). Such studies are designed to investigate the distribution of injury within a population, as well as recording information potentially relevant to such injury. Epidemiological studies are first line investigations and it is thus essential that a broad spectrum of data are collected.

Epidemiological studies of team sports such as soccer, rugby and cricket have shown that a specific injury can be related to a variety of variables (Ekstrand and Gilquist 1983, Roux et al 1987, Stretch 1993). It is important that all the relevant aspects are addressed. Firstly, basic data pertaining to the sample population must be collected, namely gender, age, playing position, previous injury history, stretching habits, equipment usage, pre-season training and physical fitness.

Furthermore, to allow for more accurate prediction of injury, specific information regarding the actual injury is required. It is necessary to document the time of injury (date), site, type, mechanism and severity of injury. This will facilitate the establishment of a comprehensive data base regarding specific injuries. Further investigation can then establish whether relationships exist between specific variables and the risk of injury. An example of this would be whether a relationship exists between non-participation in pre-season training and an increased risk of injury in field hockey players.

This literature review is divided into two sections. The first section will deal with the epidemiology of field hockey injuries, and the second section will examine the risk factors associated with injuries in field hockey.

## 2.2 The epidemiology of field hockey injuries

### 2.2.1 General risk of injury

There are few well conducted studies on the epidemiology of field hockey injuries. Most studies report descriptive information which is of limited value and often lacks statistics (Rose 1981, Jamison and Lee 1989). There is also considerable inconsistency among the various definitions of the term "injury" which make comparison between studies difficult.

Only a single epidemiological study on hockey injuries over the duration of a season has been reported (Rose 1981).This was a prospective study where members of the California State University Women's hockey team were monitored from 1976 to 1979. During this period 81 injuries were recorded, with ankle sprains being the most commonly reported injury (25%), followed by injuries to the knee joint (10%). No methodology was reported in this study.

This study has a number of limitations, including a failure to measure the true incidence of injury (injuries/hours of play) and a failure to record playing time lost. No definition of the term "injury" was included. There were no data regarding date of injury, playing position or mechanism of injury. Furthermore, only a small sample, from a single team of one gender (female), was monitored. Training schedule, match itinerary and coaching methods might also have affected the pattern of injury. Therefore, the data from this study cannot be extrapolated

to predict field hockey injuries elsewhere and in other teams. Considering these limitations, it is apparent that this study is of limited scientific value as a comparison to other studies of hockey injuries and epidemiological studies of other sports.

Another prospective study of field hockey injuries reported the injuries sustained over the duration of a tournament (Jamison and Lee 1989).This study recorded injuries occurring during the Australian National Championships over two successive years. The tournament was played on grass in the first year and on artificial turf the following year. The primary aim of the study was to document whether or not a difference existed in the number and type of injuries sustained on grass compared with artificial turf (Jamison and Lee 1989). In the first year 86 injuries were recorded, with 95 injuries being recorded in the second year. This translated to a risk of injury in the first year of 0.78 injuries/player, and 0.97 injuries/player in the second year. Specific findings of this study pertaining to the mechanism and type of injury will be discussed in further detail later on in this chapter, in section 2.2.8 and 2.2.9.

A limitation of this study was it's broad definition of the term "injury", which was defined as "....players were requested to report any injury no matter how slight". The majority of injuries reported were of a minor nature and consisted of contusions, abrasions, lacerations and blisters. These types of injuries accounted for 87% of all the injuries in the first year of the study, and 76% of all the injuries in the second year. Thus, although the injury risk of 0.78-0.97 injuries per player appeared high, the severity of injuries recorded must be considered.

A further limitation of the study was the method of data collection. It relied on the injured player reporting the injury to the coach, thus a potential under-reporting of injury could occur. Players may have been reluctant to admit to injury and thus risk their place in the team. It was

the coaches responsibility to complete an injury report form and then post it to the researchers. Data may thus have been lost if the coach failed to fill in the form or did not forward it to the researchers. Another limitation of the study was that the tournament was played on two different types of surface, namely grass and artificial turf, and only one gender was monitored.

It is difficult to extrapolate data from this particular study and apply it to a playing season. The difference between data obtained from a tournament situation and that obtained over the duration of a season, is that a tournament is a unique playing environment. In a tournament, matches can be played up to twice a day over a number of successive days. During a season, matches are usually played once a week. Also, a period of intense training usually precedes a tournament, which is not the case during the season. The level of competition in a tournament is also greater than that experienced in a league game. Despite these limitations, this study provides useful data pertaining to the risk of injury, as well as the type and mechanism of injury. It is one of the few epidemiological studies describing field hockey injuries.

In summary, few data exist, and those studies that have been reported have limitations (Rose 1981, Jamison and Lee 1989). What is evident is that a well conducted study of field hockey injuries is needed.

### 2.2.2 Match play

It has been well documented in other sports, for example rugby and cricket, that the majority of injuries occur during matches compared to practises (Ekstrand and Gilquist 1983, Clark et al 1990, Stretch 1993). It has been documented that 85% of all rugby injuries and 69% of all cricket injuries occur during matches (Clark et al 1990, Stretch 1993). There are no data on the risk of injury in field hockey matches compared with practices.

### 2.2.3 Gender

In other sports it has been suggested that women are more likely to suffer injuries than men when involved in comparable exercise programmes (Clark and Buckley 1980, Cox and Lenz 1984). One explanation for this observation is that women have more flexible connective tissue than men and are thus more susceptible to injury (Kowal 1980). This hypothesis is partially substantiated by the finding that women have greater laxity of the normal rotation of the knee, as well as the varus - valgus stiffness, compared to men (Bryant and Cooke 1988).

There are no epidemiological studies of field hockey where injury patterns in male and female players have been compared.

### 2.2.4 Age

The aging process is accompanied by potential negative changes in physiology (Seto and Brewster 1991). Of particular relevance to field hockey players are the changes to the muscular system. Associated with an increase in age is an increase in the number of cross-bridges between the collagen fibres. This results in a decreased extensibility of the muscle tissue, with a resultant decrease in the flexibility of the muscle (Seto and Brewster 1991).

Epidemiological studies of other sports have demonstrated varying trends in the relationship between age and injury. In cricket, players younger than 26 years sustained more injuries than the older players, although it was not documented whether this was a significant finding (Stretch 1993). In rugby, a comparison of the incidence of injury amongst schoolboy players and adult rugby players reported that the adult players experienced a higher incidence of injury

compared to the schoolboys. Adult players were also less likely to be injured in certain phases of play than schoolboys (Clark et al 1990). As the cause of most injuries is accepted as being multifactorial, it is not possible to ascribe injury risk purely on the basis of age, as factors such as intensity of play and different rules cannot be ignored.

The relationship between age and risk of injury has not been investigated in field hockey.

### 2.2.5 Time of the season

A first league field hockey season, as with the majority of other club level sports, is commonly divided into two parts which are separated by a mid-season break. The mid-season break is normally 3 weeks and usually falls over the June/July period in South Africa.

Other sports, such as rugby and cricket, demonstrate a particular pattern of injury over the duration of a playing season. The trend is that most injuries occur at the beginning of the season and after the mid-season break (Roux et al 1987, Clark et al 1990, Stretch 1993). In rugby, the incidence of injury was greatest during the first eight weeks of the season (45% of all injuries), and rose again following a break in league fixtures (Clark et al 1990). The same pattern was identified in schoolboy rugby players (Roux et al 1987).

In cricket it has been shown that the majority of injuries (60%) occur in the beginning of the season. This has been attributed to the lack of off-season training followed by intense fitness training in the early season (Stretch 1993).

It is hypothesised that the increase in injury after the mid-season break is a result of decreased activity during the break with the subsequent loss of skill, strength and fitness. No study has documented the influence of the time of the season on the risk of injury in field hockey.

### 2.2.6 Player position

The various player positions in field hockey can be grouped into four categories, namely strikers, midfielders, defenders and goalkeepers. The most attacking players are referred to as strikers and they are the designated goal scorers. Immediately behind the strikers are the midfielders, who are also known as links. Their function is to distribute the ball from the defenders to the strikers. Further back are the defenders, who consist of the halves and a sweeper (deepest of the defenders). The last line of defence is the goalkeeper.

In other sports, players in specific positions are predisposed to a different injury risk and type of injury (Roux et al 1987, Clark et al 1990, Stretch 1993). The relationship between position and injury in field hockey players has not yet been established.

However, the physiological requirements of field hockey have been related to player position by various researchers (Johnson and Watson 1968, Verma et al 1979, Bhanot and Sidhu 1983). Early investigations reported physiological differences between players in different positions. Certain studies have reported that the greatest physiological differences occurred between players in positions most distant from each other, particularly strikers and defenders (Kansal et al 1980, Ready and van der Merwe 1986).

Most studies reported strikers and goalkeepers as having the greatest muscle power, measured using the vertical stair run test or standing broad jump (Verma et al 1979, Kansal et al 1980, Ready and van der Merwe 1986). However, a study of elite English female players reported strikers and midfielders performing better in the standing broad jump test, compared to defenders and goalkeepers (Bale and McNaught-Davis 1983).

It was also shown that oxygen-independent muscle capacity differed between players in different positions, although the results were not as conclusive. Two studies of international Indian players showed that goalkeepers, followed by strikers had greater oxygen-independent capacity, compared with either midfielders or defenders (Verma et al 1979, Bhanot and Sidhu 1983). A similar study of Canadian international players reported strikers as having the greatest oxygen-independent capacity (Ready and van der Merwe 1986).

A study of Indian players reported that forwards possessed the greatest VO max, followed by the midfielders, defenders and goalkeepers (Kansal et al 1980). These results were the same as those recorded in Canadian players (Ready and van der Merwe 1986) and English players (Bale and McNaught-Davis 1983).

On the basis of these studies it tempting to ascribe a definitive physical profile to each specific position. However, it is important to note that these studies were conducted a number of years ago, in a period when positional roles were more rigidly defined and adhered to, which in turn dictated a specific type of play. With the advent of artificial turf, and the resultant skill levels and speed attainable on such a surface, more frequent interchanging between the various positions is evident. This has resulted in a more open style of play.

It is thus probable that current systems of play have blurred the positional differences that were evident in earlier investigations, as similar physical demands are now placed on all players, with players being required to be competent in all the outfield positions (Reilly 1992). A more recent study reporting the physiological profiles of 24 English women players substantiates such an hypothesis. This study failed to separate the players according to position on the basis of their physiological profiles (Reilly and Bretherton 1986).

On the basis of this finding, coupled with the knowledge that positions are not as specific as in the past, it may be hypothesised that physical requirements are no longer unique to a particular position.

The relationship between player position and injury may be determined by the type of activity that the player is involved in during play. For instance, strikers may be required to dive to deflect a crossed ball towards goal or to prevent the ball from going over the baseline. Such an action may result in a specific type injury. Defenders are often required to be between the ball and the goal when a shot at the goal is taken, and may be struck by a lifted ball or an uncontrolled strike.

Goalkeepers are exposed to a different playing environment than outfield players, as they are usually the last line of defence, their function being to prevent a goal from being scored. In doing so they are allowed to use their hands and feet, and often dive to the ground in order to attempt to clear the ball. Therefore, it is expected that goalkeepers should present with a different pattern of injury compared to outfield players.

However, no previous studies of hockey injuries have specified whether the different player positions have different injury risks, or whether specific types of injury can be related to playing in a certain position.

### 2.2.7 Anatomical site of injury

Specific anatomical sites for injuries in field hockey have been identified (Rose 1981, Cannon and James 1984, Lindgren and Maguire 1985, Sutherland 1986, Bolhuis 1986, Bolhuis 1987, Jamison and Lee 1989, Reilly and Seaton 1990, Petrick 1993). The most common anatomical sites recorded in a study of field hockey injuries over the duration of a season, were to the lower limb, predominantly the ankle (25%), followed by the knee (10%), quadriceps (9%) and the lower leg and foot (9%) (Rose 1981). Similarly, epidemiological studies of tournaments also show that lower limb injury was more common. In two tournaments over two successive years, injuries to the lower limb accounted for 58-77% of all injuries (Jamison and Lee 1989).

#### 2.2.7.1 Injuries to the upper body

For the purposes of our study, the upper body can described as being the anatomical area above the waist, excluding the lumbar spine. To date, epidemiological studies have indicated that lower body injuries are more common than upper body injuries (Rose 1981, Jamison and Lee 1989). A study of injuries sustained over the duration of a tournament reported that 22-25% of injuries were to the upper body (Jamison and Lee 1989). In one study conducted over a four year period, 20% of the injuries were to the upper body (Rose 1981). Specific areas of injury included the head (4%), face (6%) and shoulder (1%).

The epidemiology of a specific anatomical site of injury within the upper body region was reported in two studies. Both studies described the epidemiology of facial injuries in field hockey (Bolhuis 1986, Bolhuis 1987). A retrospective study of 3577 recreational players in Holland reported that 32% of players had suffered a previous facial injury during their field hockey career (Bolhuis 1986). In another prospective study of dental and facial injuries in international hockey players, 62% of the respondents had suffered from a previous facial injury during their career (Bolhuis 1987).

It appears that facial injuries, although not the predominant upper body injury, occur frequently enough to be of concern to players, coaches and medical staff. It must be noted however, that it was lifetime prevalence that was reported, not seasonal incidence.

#### 2.2.7.2 Injuries to the lower body

For the purpose of our study, the lower body is described as being the anatomical area below the waist, including the lumbar spine. Epidemiological studies have shown that this is the most frequently injured region (Rose 1981, Jamison and Lee 1989). The most common specific anatomical sites injured in this region include the ankle joint, knee joint and the hamstring muscle. One prospective study reported that the ankle was the most frequently injured joint in the lower body (25% of all injuries), followed by the knee joint (10%), and the quadriceps muscle (9%) (Rose 1981). In another prospective study, over two successive years, the knee joint was injured most frequently (18-31% of all injuries) followed by the ankle joint (3-9%) and the hamstring muscle (2%) (Jamieson and Lee 1989). It therefore appears that the joints of the lower limb were more likely to be injured than soft tissues.

The epidemiology of injuries to specific anatomical sites within the lower body has also been reported. These include the lower back (Cannon and James 1984, Lindgren and Maguire 1985, Sutherland 1986, Reilly and Seaton 1990) and lower leg (Petrick 1993). Injuries to each of these anatomical sites will now be discussed in further detail.

2.2.7.2.1 **Lower back injuries**

Sustained lumbar flexion whilst dribbling the ball, channelling or tackling during field hockey has been described as an "ergonomically unsound position for locomotion" (Fox 1981). This position causes postural stress, which may be exacerbated by the superimposed work-rate of running (Fox 1981). It can thus be hypothesised that the unique body position of the lumbar spine required by field hockey can result in lower back injuries.

Lower back pain in field hockey players has been reported in a number of studies (Twomey and Taylor 1982, Cannon and James 1984, Lindgren and Magiure 1985, Pope et al 1985, Sutherland 1986, Troup et al 1987, Reilly and Seaton 1990).

In one retrospective study over a four year period, it was reported that 7.6% of patients referred to a back pain clinic were hockey players (Cannon and James 1984). Although this study gives some indication that back injuries are common in hockey players, internal bias is present as the study was only representative of patients presenting at that particular clinic. Therefore an element of self-selection was evident.

In another study, a survey of male hockey clubs in a single region in England showed that 53% of hockey players who responded to a questionnaire suffered from lower back pain (Reilly and

Seaton 1990). In this study, a total of 100 questionnaires were distributed with an 81% response rate. This was a good response and generated the impression that the results were indeed reflective of the general hockey playing population.

In a report of overuse injuries in the Australian National team, thoracolumbar injuries accounted for 33% of the overuse injuries in males, and 58% of the overuse injuries in females (Lindgren and Maguire 1985). It is thus evident, based on the findings of the afore-mentioned studies, that lower back pain is common in hockey players.

Potential aetiological factors for the occurrence of lower back pain in hockey players have also been investigated. Three possible aetiological factors for the development of lower back pain in hockey players have been suggested in the literature.

The first hypothesis is that prolonged lumbar flexion causes "creep" in the posterior portion of the intervertebral disc, the posterior ligaments and the facet joints (Twomey and Taylor 1982). This is associated with an increased retrovertebral shift of the instantaneous axis of rotation (IAR) of a motion segment (Bogduk 1989). Creep and an alteration in the IAR can change the facet joint mechanics and thereby decrease spinal range of motion, in particular, lumbar extension (Bogduk 1989, Twomey and Taylor 1982). This then results in pain due to facet joint, posterior disc and posterior ligament irritation.

This hypothesis has been partially addressed in a well conducted study scientific study (Reilly and Seaton 1990). The aim of this study was to establish the degree of spinal shrinkage that resulted from running in a position of sustained lumbar flexion. Seven male hockey players completed a 7 minute run at 8.5 km/h whilst dribbling a ball.

Spinal shrinkage was measured as the loss in stature between pre and post-exercise condition, using a stadiometer (described in Boocock et al 1986).

The study was well controlled and all seven subjects were familiarized with the testing procedure before the study. All the testing was conducted at a particular time of day to account for circadian variations. Prior to testing all subjects adopted the Fowlers recovery position for ten minutes. After running was completed a period of two minutes rest was allowed so that the respiratory rate could decrease sufficiently to allow for accurate measurement. The results of this study showed that spinal shrinkage occurred at a rate of 0.4 mm/min in subjects running on a treadmill. This demonstrates that there is a measurable physiological change which is associated with running in a position of sustained lumbar flexion. However, the results of this study do not relate the lower back pain that hockey players experience in a direct cause-effect relationship to spinal shrinkage.

A second hypothesis for the development of lower back pain in hockey players is that of decreased range of motion in the lumbar spine, particularly extension (Bogduk 1989, Twomey and Taylor 1982).

Lumbosacral range of motion in elite female hockey players who experienced lower back pain has been compared to non-injured hockey players and non-hockey-playing controls (Fenety and Kumar 1992). In this study, lumbosacral range of motion was measured by a photographic technique in which subjects wore spinal motion markers. The limits of lumbosacral sagittal range of motion in standing were determined. The group that experienced lumbar pain had 12 to 18 degrees less extension ($p < 0.1$) and 18 to 24 degrees less total range of motion ($p<0.001$) than non-injured hockey players and the non-hockey-playing control group (Fenety and Kumar 1992).

The report that a decreased range of motion in the lumbar spine was associated with lower back pain was not an isolated finding. In a study of 321 males with lower back pain, a 10% decrease in lumbar extension in the mild and severe pain groups was noted when compared to the pain-free control group (Pope et al 1985).

However, in the study of elite female hockey players no difference between the range of motion of non-injured hockey players and non-hockey playing controls was documented (Fenety and Kumar 1992). A possible conclusion that can be drawn based on the findings of these studies is that, although there is an association between decreased range of motion in the lumbar spine and lower back pain, it may be that the pain is responsible for limiting the movement as opposed to the decreased movement resulting in pain.

No clinical evidence was provided to suggest that there was any relationship between decreased extension prior to injury that then made that player more susceptible to a lower back injury. This is an area which requires further investigation.

The third hypothesis is that decreased isokinetic trunk strength may predispose hockey players to the development of lower back pain. This has been investigated in a group of elite female hockey players (Fenety and Kumar 1992). Eccentric and concentric isokinetic trunk flexion and extension torques of hockey players with lower back pain, non-injured hockey players and non-hockey-playing controls were recorded. These torques were measured in sitting through 60 degrees of trunk movement using a Kin-Com dynamometer at 60 degrees per second. No significant differences in strength were evident between non-injured hockey players and non-hockey-playing controls. However, hockey players with lower back pain exhibited peak and average extension torques that were weaker than those of the non-hockey-playing control.

It must be noted that decreased extension torques in the hockey players with lower back pain may be because of the inhibition caused by pain (weak because of pain) as opposed to weaker trunk extensor musculature predisposing to lower back pain (pain because of weakness). This requires further investigation in a prospective controlled study.

It is clear that lower back pain is a common injury in hockey players. The aetiology of lower back pain in hockey players has been attributed to various reasons. Factors documented by reaearch studies include the influence of creep, decreased lumbosacral extension and decreased isokinetic trunk strength (Twomey and Taylor 1982, Bogduk 1989, Reilly and Seaton 1990, Fenety and Kumar 1992).

#### 2.2.7.2.2 **Lower leg injuries**

Lower leg pain can be described as being pain experienced in the tibial region (anterior, medial, posterior). A prospective study of 157 schoolgirl hockey players from two different regions documented lower leg pain throughout the monitored season (Petrick 1993). Data were obtained by means of a questionnaire. Unfortunately, the response rate was not documented. In this study, lower leg pain was defined as an overuse injury of the tibia and excluded ankle injury, extrinsic injury and direct trauma. A total of 43 lower leg injuries were recorded during the season, giving a seasonal prevalence of injury of 27%. A lifetime prevalence of lower leg pain of 48% was documented.

Although the results of the study indicate that injury to the lower leg is common (seasonal prevalence of 27%; lifetime prevalence of 48%), the generalizability of the results to other hockey playing populations is limited, as they are representative of only one gender, and a particular age group and level of play.

Further limitations of this study were that the levels of fitness and skill in adult club or national players is greater than that of the schoolgirl players. Another limitation is that the sample population played on grass, whereas club and national and international players play predominantly on artificial turf. Thus the different surfaces may influence the aetiology of the injury. However, this study does indicate that lower leg pains occurs in a hockey-playing population.

In summary, injuries to the lower body in field hockey are more common than injuries to the upper body. Although epidemiological studies (Rose 1981, Jamison and Lee 1989) have frequently reported injuries to the ankle and knee joints, and hamstring muscle, very little specific data exists as to the particular aetiology of these injuries.

### 2.2.8 Classification of injuries in field hockey

Injury can be classified according to the tissues that are injured. Injuries could thus be referred to as muscle strains, ligament sprains, bony, tendon, or "other" injuries, which for the purposes of our study will include abrasions, lacerations, haematomas, effusions and blisters.

Previous studies of field hockey show that injuries were mostly abrasions, contusions and lacerations (64-90% of all injuries), followed by muscle (5-12%) and ligament (2%) injury (Rose 1981, Jamison and Lee 1989). Abrasions, contusions and lacerations tend to be less serious and rarely result in time lost from playing hockey. However, this is an observation that cannot be substantiated as studies in field hockey have not documented time lost due to injury. Although it is important to be aware of minor injuries, they rarely result in time lost from playing hockey and thus have a negligable impact on the players, or the game itself.

### 2.2.9 Mechanism of injury in field hockey

The mechanism of injury refers to the phase of play during which the injury was sustained. In only one epidemiological study have mechanisms of injury in field hockey been reported (Jamison and Lee 1989). In this study the mechanisms of injury were classified as either extrinsic - resulting from an external force, including impact of the ball or stick, collision with another player or falling, or intrinsic - resulting from internal strain on the body. The study recorded injuries sustained during the Australian National Championship, over two successive years. Extrinsic injuries predominated, and accounted for 82-88% of field hockey injuries (Jamison and Lee 1989). In a tournament situation it is expected that extrinsic injuries would be common because of the intense competition associated with such a playing environment. The most common mechanism of injury was being hit by the ball (32-42%), followed by being hit with the stick whilst either tackling or being tackled (23-26%), falling (12-14%) and collisions (9-11%). Intrinsic injuries accounted for 12-18% of the total number of injuries reported (Jamison and Lee 1989).

In summary, the majority of field hockey injuries appear to be extrinsic in nature. The fact that all data on the mechanism of injury in field hockey were reported in tournament situations may account for this finding. Players would not be expected to report overuse injuries because there was not enough exposure time. However, field hockey is essentially a contact sport and involves equipment, such as sticks and a ball, that are potentially dangerous. The nature of the sport is also characterised by sudden directional changes and body contact with other players. There is thus the danger of falling, slipping, being hit with either ball or stick or colliding with another player.

### 2.2.10 Surface

Field hockey can be played on either grass or artificial turf. The surface that is predominantly used for practices and matches at both a club and national and international level is artificial turf. The characteristics and advantages of artificial turf will be discussed in detail in the following section. A number of studies have documented the differences in the incidence of injury between grass and artificial turf.

#### 2.2.10.1 Artificial turf

Artificial playing surfaces are increasingly being used for competitive sport. At international level, all field hockey matches are played on such surfaces (Reilly 1992). In South Africa, the majority of first league matches, and all national and international matches are played on artificial turf.

The advantage of artificial turf is that it is consistent because of its' even and uniform nature. The uniformity allows for improved ball control, and subsequently an enhanced ability to exercise personal skill and ball retention. It also permits an increased running speed, which in turn increases the collision force and thus the potential for more serious injury (Malhotra et al 1983).

Artificial turf does have the disadvantage that the padding wears with age. This results in a diminished shock absorbing capability and it also alters the traction qualities (Kulund 1982). Even new artificial turf has a base which is less shock absorbent in comparison to grass. One study has documented that artificial turf absorbs as much as 10% less energy compared to grass (Larson and Osternig 1974).

A study on the effect of temperature on the rotational torsion resistance of football shoes to artificial turf, reported that release co-efficients differed both in and among shoe models across a range of turf temperatures (Torg et al 1996). It was reported that the combination of increased turf temperature and a high number of cleats resulted in increased friction between the shoe and the playing surface. This was postulated to increase the "foot fix", and hence the risk of injury to the ankle and knee joints.

This finding suggests that wet, thus cooler, artificial turf, combined with boots with fewer cleats, may have a potentially lower risk of injury than dry turf (Torg et al 1996). However, no prospective study has investigated such a relationship.

Artificial turf has substantially increased the physiological requirements for the game, by increasing the playing time and decreasing the number of interruptions (Malhotra et al 1983). The performances in international women's matches between grass and artificial turf surfaces have been compared. On average there were significantly more touches per possession on artificial turf than on grass, and as a result of this the players ran more with the ball on the artificial pitch (Malhotra et al 1983).

The advantage of artificial turf surfaces for field hockey are substantial. This surface improves the level of skill and speed of the game and the quality of hockey.

### 2.2.10.2 Injury risk on grass and artificial turf surfaces

The development and use of artificial playing surfaces in hockey has raised the question whether injuries sustained on these surfaces differ from those sustained on grass surfaces. A number of studies have documented the difference in injury risk, as well as injury type between playing surfaces.

Studies have compared the injury rates on artificial and grass surfaces in American football players (Bromwell et al 1972, Larson and Osternig 1974, Bowers et al 1975, Keene et al 1980). The results of two separate studies showed that there was an increased rate of injury on the artificial surfaces compared to grass. In particular, the knee joint was at greatest risk (Larson and Osternig 1974, Bowers et al 1975). In another football study, the overall injury risk was also higher on artificial turf compared to grass, but the injuries were less serious than those sustained while playing on grass (Bortolin 1970). Although these studies are of a different sport, they still indicate the potential injury risk associated with artificial turf.

In one prospective study, injury rates during the Australian National Women's Hockey Championships over two successive years were compared. The rate of injury on artificial turf (0.97 injuries/player) was higher than that recorded on grass (0.78 injuries/player) (Jamison and Lee 1989).

There was a significantly lower frequency of joint related injuries to the lower limb on artificial turf (37% of all injuries), compared to grass (53%) (Jamison and Lee 1989).However, the grass surface was apparently in a very poor condition (as was stated in the study) and thus may have contributed to the large number of knee and ankle injuries.

The improved traction provided by artificial turf is a possible factor contributing to the increased susceptibility to injury. This increased traction is known as "foot-fix" (Reilly 1992) and occurs particularly on dry turf. The cleats of the hockey boot grip the turf better than they do grass and this results in a foot that remains fixed while the body rotates during movements that require abrupt directional change. This may then predispose a player to injury of the ankle and knee and hip joints (Torg 1973).

It has also been documented that turning on artificial turf is indeed more difficult than on grass (Malhotra 1983). If the cleats did not grip as firmly, it would allow the foot to slip more easily under the player and thus minimize the risk of the injury (Andreasson et al 1986).

In summary, artificial turf has its' advantages as it improves the speed and skill of the game. However, artificial surfaces are possibly associated with an increased risk of injury, particularly ankle and knee injuries.

#### 2.2.1.1 Severity of injury in field hockey

The severity of an injury can be assessed by any of the following criteria:
-whether or not a player could complete a match or practice once injured,
-whether a player sought treatment for their injury,
- whether a player missed subsequent matches or practices due to injury.

In none of the published epidemiological studies of field hockey injuries has the severity of injury has been well documented. Most studies only reported whether or not an injury required medical attention.

Of the 81 injuries in the study of the Californian State University team over four years, 56 (69%) were seen by a physician (Rose 1981). The four second degree ankle sprains (5%) recorded resulted in a two to three week absence from hockey. The four most serious knee injuries (5%) required orthopaedic consultation and averaged three weeks off from playing hockey (Rose 1981). Two (2%) of the injuries were diagnosed as meniscal tears, with the other two (2%) being a collateral ligament sprain and osteochondritis dissecans.

In international hockey players at a World Cup tournament, 62% of the players reported suffering a facial injury at some time in their career. Of these, 54% had injuries that required a consultation with a doctor or dentist because of the injury (Bolhuis 1987).

Seventeen (41%) of the 43 lower leg overuse injuries sustained by schoolgirl hockey players resulted in the injured player seeking medical advice (Petrick 1993).

No information regarding further management or time off hockey was furnished in any of the these studies. It is thus difficult to accurately describe the severity of the injuries in field hockey. This requires further investigation.

### 2.2.12 Summary: Epidemiology of injuries in field hockey

No previous studies have documented the true incidence of injury (injuries/1000 hours of play) in field hockey players, although a number of studies on field hockey injuries have been conducted. These are either epidemiological studies or case series of a particular type of injury. Thus the overall risks of injury, both injury patterns and severity, in field hockey are difficult to determine from this review.

It is evident from the literature review that substantial deficiencies exist in the current information on field hockey injuries. Such deficiencies need to be addressed in order to determine the magnitude of the problem, identify high risk groups for injury and emergent problems, and generate hypotheses of injury risk factors.

## 2.3 A review of the risk factors associated with field hockey injuries

### 2.3.1 Physiological requirements of field hockey

#### 2.3.1.1 Introduction

Field hockey is a sport that is characterised by dribbling the ball, moving quickly in a semi-crouched position and lunging to tackle or intercept. Rapid bursts of speed are often coupled with sudden directional changes and the game is played at a fast pace (Reilly 1992).

An analysis of the physiological cost and energy expenditure of playing hockey has placed field hockey in the category of "heavy exercise", with the reported mean oxygen consumption (VO) during a game of 2.26 l/min. Energy expenditure during field hockey has been estimated as 36 - 50 kilojoules per minute (Reilly 1992).

The various activities that a player is required to perform whilst playing hockey can only occur in a safe and effective manner if the player is physically conditioned to meet the physiological challenges of the game. Hockey players thus require sufficient flexibility, power, speed and endurance to withstand the physical demands that are imposed upon them by the game. It can be hypothesised that the risk of injury may be greater in a player who develops premature fatigue during a game because of poor conditioning.

The relationships between the physiological requirements of the game (flexibility, power, speed and endurance), and their possible contribution to injury risk will now be discussed.

### 2.3.1.2 Flexibility

Flexibility can be defined as being the range of motion of a specific joint (Siff 1990). Running in a semi-crouched position requires spinal flexibility, anterior hip flexibility and adequate hamstring muscle length. Both spinal and hamstring muscle flexibility combine to allow this movement, hence an optimal playing posture. It can therefore be hypothesised that adequate flexibility may prevent or decrease the risk of injury (Ekstrand and Gilquist 1983, Safran et al 1988, Scott 1991, Reider 1991).

A shortened muscle may also create an imbalance at a joint and result in an abnormal postural alignment. This malalignment may lead to joint dysfunction and result in injury (Turner and Bandy 1988). This implies that a lack of flexibility may predispose to injury because it inhibits the correct execution of a movement (Travers 1980). It has also been documented that muscle strains occur at a critical tension and this tension is proportional to the flexibility of the muscle (Safran et al 1988).

There are no studies that have examined the relationship between flexibility and injury in hockey players. However, studies of other sports have suggested that muscle inflexibility may be related to an increased risk of injury (Cahill et al 1978, Ekstrand and Gilquist 1983, Heiser et al 1984, Greipp et al 1985, Reid 1987, Safran et al 1988, Reider et al 1991, Smith 1994), although this has not been well studied. A probable reason for the sparse evidence in support of this belief is that the aetiology of most injuries is multifactorial. It is thus difficult to

attribute injury to one particular variable, in this case, flexibility. However, as these studies do provide evidence to support the association of increased flexibility and decreased injury risk, such a hypothesis is worth investigating.

Hamstring flexibility has been documented in a study of South African club hockey players (Scott 1991), but the findings were not related to injury in any way. Players in this study were tested using the sit and reach test.

The sit and reach test is the most commonly used field test to determine hamstring musculotendonous flexibility. The validity and reliability of this measurement have been established (Wells and Dillon 1952, Jackson and Baker 1986, Allen 1988, Jackson 1989). A recent research report has demonstrated a good correlation (r=0.76) between the sit and reach test (SRT) score and the inclinometer measurement of the hip joint angle (Cornbleet and Woolsey 1996). Hip joint angle measurements may be superior to the sit and reach test because they are not influenced by spinal mobility. The sit and reach test is however still of value in large scale field testing because of its ease and speed of application.

In a study of elite South African club hockey players, it was documented that flexibility as measured by the sit and reach test gave rise to a wide range of values, ranging from minus 20 cm to 26.2cm (Scott 1991). The overall mean was 9.3cm, with national players being more flexible than club players, with an average of 12cm. According to the flexibility rating scale, the results of the group as a whole rated as "marginal" and the national players as "very good" (Corbin et al 1981). The aim of this study was to establish morphological characteristics and no injury history was documented. Therefore, no hypothesis can be generated regarding the relationship between the sit and reach results and injury risk.

The relationship between injuries and decreased flexibility in field hockey players requires further investigation.

Although a certain amount of flexibility is determined genetically, an increase or maintenance of flexibility can be achieved by regular stretching (Noakes 1987). Benefits attributable to stretching include an increase in the range of motion of the joint, decreased predisposition to injury, decreased muscle soreness and enhanced athletic performance (Noakes 1987, Anderson 1988, Knapnik et al 1991).

A recent literature review pertaining to stretching protocol proposed the following recommendations upon summary of the literature sourced (Smith 1994).

- stretch both before and after activity
- stretch duration to 15 sec. - 20 sec. per stretch
- repeat each stretch 3 to 5 times.

A more recent investigation of stretching protocol confirmed these recommendations, but reported that a slightly longer stretch duration (30 seconds) was optimal (Hughes 1996).

In a prospective study of the stretching programmes of athletes participating in various sports at university level, it was documented that the vast majority of athletes only stretched prior to activity, maintained their stretch for between 10 - 15 seconds, and only repeated each stretch once or twice (Fricker and Ferguson 1994).

It is thus important to note that although stretching improves flexibility, it should be performed in the correct manner, with particular reference to the duration of the stretch and the number of repetitions.

### 2.3.1.3 Muscle power and injury risk in field hockey

Muscle power can be defined as being the explosive strength of a muscle (Bruckner and Khan 1993). The stronger a muscle the more energy it can absorb, with the ability to absorb more energy possibly protecting the muscle against injury (Mair et al 1996). The game of hockey requires rapid acceleration and sudden changes in direction. Therefore, lower limb strength, particularly the quadriceps muscle group, is important. These muscles are used concentrically and eccentrically during running.

Although a number of studies have been conducted to determine lower limb power in field hockey players (Bale and McNaught-Davis 1983, Reilly and Bretherton 1986, Scott 1991), the association between muscle power and injury risk in field hockey has not been investigated.

There is anecdotal evidence to support the hypothesis that decreased muscle power is associated with an increased risk of injury in field hockey. In 1994, members of the South African womans hockey team sustained a large number of quadricep muscle strains (Millson 1994). After following a specific quadriceps strengthening program the frequency of this injury decreased noticably (Millson 1995).

There is some evidence to support the hypothesis of increased muscle power protecting against injury in other sports (Dominguez 1978, Gruchow and Pelletier 1979, Fleck and Fleck 1986). One study documented that "tennis elbow" occurred less frequently in players that included some form of resistence training in their routines. Players who were placed on a preventative resistence training program subsequent to the development of "tennis elbow"

reported a decreased recurrence of the injury (Gruchow and Pelletier 1979). It is thus possible that a similar relationship may be found in hockey players, in that increased muscle power may result in a decreased risk of injury.

The most practical field test of lower limb muscle power is the standing broad jump. This test has been validated and is reliable (Cooper 1963).

A study of the morphological characteristics of male South African club hockey players showed that the players achieved a mean value of 230 cm $\pm$ 18 cm (Scott 1991). This value was classified as "very good" according to Corbin's power-rating scale (1981). Two other studies, of English female players, documented similar results (180$\pm$17 cm to 200$\pm$18 cm) (Bale and McNaught-Davis 1983, Reilly and Bretherton 1986). One of the studies documented positional differences in the results: strikers - 184 cm, midfielders - 186.3 cm, defenders - 174 cm, goalkeepers - 181.3 cm (Bale and McNaught-Davis 1983).

Although all the aforementioned studies of lower limb muscle power provide a database to which other studies can be compared, such information would be more pertinent if the standing broad jump results could be related to injury risk.

#### 2.3.1.4 Muscle endurance and injury risk in field hockey

Muscle endurance is defined as the ability of muscle to resist fatigue (Bruckner and Khan 1993). Muscle fatigue may predispose to injury because of an inability to generate force in the muscle. The exercise intensity in hockey has been estimated by motion analysis of match play (Reilly 1992). Work rate profiles obtained from such analysis indicate that relative

contributions of oxygen dependant and oxygen independent energy pathways to total metabolism (Fox 1984, Sharkey 1986). In the first study, the oxygen independent pathway contributed 70% to the total energy expenditure, the remaining 30% attributed to the oxygen dependant pathway (Fox 1984). In the second study, oxygen independent pathways contributed 40%, and oxygen dependant pathways 60%, to the total energy expenditure (Sharkey 1986).

The findings of the second study are likely to be more relevant to modern hockey. This is because the game, with its potential for continuous activity, appears to place demands on the oxygen dependant system with frequent superimposed efforts utilising the oxygen independent system (Reilly 1992).

This hypothesis is partially supported by the finding that hockey players have a significantly greater proportion of fast oxidative glycolytic and slower oxidative skeletal muscle fibres in muscle biopsy studies than non-hockey playing controls (Prince et al 1977 ).

Previous studies of the maximum oxygen dependent capacity of hockey players have all assumed that VO max was the best indicator of endurance capacity (Rate and Pyke 1978, Reilly and Secher 1980, Ready and van der Merwe 1986). The assumption of such a test was that it was oxygen uptake that determined exercise capacity. Although this paradigm has recently been challenged (Noakes 1998), the results of studies where VO max has been documented are still of value. The VO max of elite female hockey players ranges from 45 l/min - 59 l/min and males from 48 l/min - 65 l/min (Reilly and Secher 1980).

In summary, no research studies have documented the relationship between muscle endurance and injury in hockey players. However, it is possible that a fatigued muscle may be predisposed to injury because of the inability to generate adequate force.

### 2.3.2 Equipment and injury risk in field hockey

#### 2.3.2.1 Introduction

The rules of field hockey require that the players be equipped in a specific manner. Items such as footwear, clothing and standard hockey sticks are compulsory. The use of other items, including shinpads, mouth protectors, finger guards and knee and ankle braces, is optional.

Of the compulsory items, only footwear is relevant in terms of injury risk. A number of studies have investigated the relationship between shoe and surface (Torg 1973, Torg 1974, Andreasson et al 1986, Torg et al 1996). In the majority of these studies the traction qualities of various boots were investigated, although no particular type of boot was implicated in an increased injury risk. In none of the epidemiological studies of field hockey injuries was the relationship between footwear and injury risk documented (Rose 1981, Jamison and Lee 1989).

The relationship between the non-compulsory, protective items and injury risk has not been investigated. The only exception is the mouth protector, the use of which has been established in two prospective studies (Bolhuis 1986, Bolhuis 1987).

### 2.3.2.2 Footwear and injury risk in field hockey

At the time when hockey was played predominantly on grass surfaces, the footwear resembled that of soccer players. With the introduction of the artificial playing surfaces, specific artificial turf shoes were designed. In the design of hockey footwear, some of the technology was adapted from the American gridiron football shoes. Today a wide variety of hockey boots are available. In South Africa there are approximately nine different brand names, with each brand having a number of different styles.

Most hockey boots have rubber cleats (small studs) on their soles, but the arrangement and number of the cleats vary from boot to boot. Anecdotal evidence from players, coaches and physiotherapists suggest that the present range of footwear is not adequate. It has been suggested that those boots with cleats that protrude out from the sides result in ankle injuries, due to the increased grip of the boot to the turf. Others boots are associated with poor internal support, low heel counter and relatively thin sole and these factors may predispose the wearer to lower limb injuries. However, all these hypotheses still have to be substantiated in well conducted clinical trials.

The fixation of the foot on the playing surface is recognised as a possible cause of knee and ankle injuries (Torg 1976). The cleats on an artificial turf shoe fix the foot to the turf. This in turn fixes the foot, so that the joints of the lower limb have to accommodate any intrinsic or extrinsic movement forces (Andreasson et al 1986). The application of a force to the knee or ankle in a plane other that of normal joint motion can result in an injury if the force exceeds the elastic capabilities of the support structures (Torg et al 1996).

In one study, the incidence and severity of knee injuries in players wearing high torque producing shoes (cleated shoes) was significantly higher compared to players wearing moulded sole soccer type shoes (non-cleated) (Torg 1974).

The frictional force between the shoe and the surface has been shown to be independent of running speed in the range 1 - 5 m/s. The torque generated in the foot was found to be dependant on the physical distribution of the texture of the sole (Andreasson et al 1986). Non-cleated shoes were associated with the production of less torque compared to cleated shoes, whilst running on the same surface.

It therefore appears that cleated boots may predispose a player to injury because of their increased grip on artificial turf. However, no epidemiological study has been conducted to test this hypothesis in hockey players.

2.3.2.3. Mouth protectors and injury risk in field hockey

Mouth protectors, also known as gum guards, are rigid plastic guards which fit over the teeth. They can be obtained in a variety of models. It is believed that the majority of dental trauma can be prevented by wearing a mouthguard, which is reported to absorb the impact of a blow and thus protect the teeth (Bolhuis 1987).

In a survey of 314 players, from 15 countries, during three international tournaments, 43% had a mouth protector. Most players wore it during match play, but only 20% of the players wore it during both matches and practices. Women were reported as wearing mouth guards twice as frequently as men (Bolhuis 1987).

It has been documented that dental trauma is common in field hockey players (Bolhuis 1986, Bolhuis 1987). However, few players appear to wear a mouth protector which could prevent or at least minimize such injury.

### 2.3.4 Summary of the injury risk factors in field hockey

The risk factors associated with injuries in field hockey can be related to the physiological requirements of the game, as well as the use of equipment by players.

The physiological demands of the game are such that players require adequate flexibility, power, speed and endurance. The relationship of these factors to injury risk however, has not been well investigated.

Similarly, the optimal use of equipment may decrease the risk of injury in field hockey. The relationship between footwear and injury risk, as well as mouth protectors and dental injuries require further investigation.

# Chapter Three

# METHODOLOGY

**Contents**

## 3.1 Introduction

The methodology of the study was designed to allow the formulation of a player profile of the sample population, with specific reference to past injury history, pre-season training methods, stretching protocols and equipment usage. The pre-season fitness of the sample population was also established.

The sample population was monitored throughout the season for injuries and the relevant injury data recorded.

## 3.2 Aims of the study

The aim of the study was to establish the epidemiology of injury and risk factors for injury in field hockey players over the duration of one playing season. The risk factors for injury that were investigated included previous injury, pre-season training methods, pre-season fitness, stretching habits, equipment, gender, age, playing position, time of season, game status and playing surface.

## 3.3 Research Design

This study was a prospective cohort study of the epidemiology of injuries sustained by first league field hockey players in the Western Cape during the 1995 hockey season, including an evaluation of risk factors for field hockey injuries.

## 3.4 Sample Population

The sample population consisted of all the hockey players, both male and female, competing in the first league in the Western Cape ( known as the Grand Challenge ) in the 1995 season.

The Grand Challenge comprised twenty (20) teams in total. Each team fielded approximately thirteen players. Thus, a total research population of two hundred and twenty-two hockey players (222) were studied. There were an equal number of male (n=10) and female (n=10) teams, as well as an equal number of male (n=111) and female (n=111) players in the sample population.

The motivation to study players from the Grand Challenge only, as opposed to including players from other leagues, was as follows. Firstly, players in the Grand Challenge practised regularly, and played matches exclusively, on artificial turf. Artificial turf is the playing surface utilized at both national and international level, and results obtained from this study could therefore be extrapolated to national and international players. In lower league teams the field surface that is predominantly played upon is grass.

Secondly, Grand Challenge players were an accessible population. These players compare favourably with respect to playing ability to national team players, which are often not as accessible. Therefore, results obtained from the Grand Challenge players would be more relevant to players at national level because of the similarity in playing ability. This would not be the case if players from the lower leagues were included in the sample population.

All the teams participating in the Grand Challenge were included in the study population to eliminate the possibility of selection bias and also to control the population validity of the study. The selection of all teams also ensures a broad study base which increases the generalizability of this study to other populations of hockey players.

The potential to extrapolate the results obtained in this study to other first league hockey players throughout the country was enhanced as the majority of these teams are exposed to similar playing conditions as the teams in this study population. These playing conditions include regular practices on artificial turf, playing all matches on turf, and a similar playing schedule over the season.

The Western Province Hockey Association was approached for a list of all the chairpersons of the clubs whose teams were in the proposed study population. A brief outline of the study and its objectives was handed to each chairperson at the council meeting held prior to the start of the 1995 hockey season. The contact numbers for the coaches of all the first league teams were obtained from the relevant chairperson.

The coaches of the respective teams were contacted by telephone prior to the start of the season. The details of the study were explained to them. The responsibilities that they would be required to undertake on behalf of the study were detailed at this time. All twenty coaches agreed to participate in the study.

## 3.5 Experimental procedure

### 3.5.1 Introduction

The study consisted of two parts. The first part of the study took place prior to the start of the season and had two aims. Firstly, to collect relevant player information to allow for the formulation of a player profile (Player profile questionnaire - Appendix 1). Secondly, to establish the players pre-season fitness (Pre-season fitness assessment - Appendix 2). The player profile questionnaire established morphological data, training methods and equipment usage. The pre-season fitness assessment documented flexibility, muscle power, speed and muscle endurance.

Part I of the study (player profile questionnaire, pre-season fitness assessment) was implemented between mid-March and mid-April 1995.The first match of the season was on 20 April 1995. All the coaches were contacted and a convenient date to complete questionnaires and perform the fitness testing was determined. On the day of testing, the researcher informed the players of the objectives of the study and what would be required of them. This included descriptions of the physiological testing, how to complete the questionnaire, as well as details of part two of the project, which entailed the reporting of injuries. Verbal consent from the players was obtained at this time.

Part II of the study was a prospective cohort study to document the incidence of hockey injuries over one season. All the players injured during the 1995 hockey season were interviewed by the researcher and an injury report form was completed (Appendix 3). The researcher conducted both the first and second parts of the study.

**Part I: Player profile questionnaire and pre-season fitness assessment**

### 3.5.2 Player profile questionnaire

The player profile questionnaire was completed before the pre-season fitness assessment. The questionnaire (Appendix 1) was designed to obtain information regarding previous injury history (1994), training habits, stretching protocols and equipment. The information from the questionnaires was later related to the results that players obtained in the pre-season fitness assessment, as well as any injury that those players sustained during the season. This was to determine whether a relationship existed between any of the variables examined by the player profile questionnaire and fitness test results, or predisposition to injury. Any association between results of the fitness tests and predisposition to injury was also investigated. The relevance of previous injury history to current injury, the influence of training habits and stretching protocols on both pre-season fitness results and predisposition to injury, as well as the relationship of equipment or lack thereof to injury was thus determined.

Prior to the study, the questionnaire was pilot-tested on ten hockey players that were not part of the research population. Relevant alterations were made on the advice of the players, the research supervisor and the statistician.

Subjects were asked to complete the single page questionnaire (Appendix 1), which consisted of three sections. The first section contained information regarding name, telephone number, age, sex, club, playing position, and a previous injury history relevant to the previous playing season (1994). Data were collected only on the previous seasons injuries in order to minimise any potential recall bias associated with retrospective data collection.

The second section of the questionnaire established players training habits. Subjects provided details regarding their participation in other sports (this referred to participation in another sport or physical activity twice or more a week, during the winter hockey season). The pre-season training methods of the players were also questioned. Pre-season training was defined as any training undertaken by the player prior to the start of the hockey season. It's purpose was to condition a player to the physical demands that would be placed upon them during the season by improving their level of fitness. The stretching habits of the players, including the type and duration of stretch, were documented.

The third section of the questionnaire dealt with the use of equipment, such as mouth protectors, footwear and protective braces and supportive devices.

The questionnaires took approximately five minutes to complete, and on completion were handed directly to the researcher. Any questions regarding the questionnaire were raised immediately and addressed by the researcher at the time of the testing.

### 3.5.3 Pre-season fitness assessment

On completion of the player profile questionnaire, the fitness assessment was performed (all the fitness assessments were conducted between 17h00 and 19h00.) The subjects were instructed to jog slowly twice around the perimeter of the hockey field as a warm-up (a total distance of $\pm$585 m). The players were then asked to perform their normal stretching regime.

Once warmed up and stretched, the pre-season fitness assessment could proceed. All the subjects names were recorded onto the Testing Data Sheet (Appendix 4). The order in which

the names appeared on this sheet was the order in which the subjects participated in each test. The only test which all the subjects performed as a group was the double winder test.

The fitness assessment consisted of the following tests:

(i) Sit and reach test, to determine hamstring flexibility

(ii) Standing broad jump, to determine lower limb muscle power

(iii) Forty metre sprint, to determine speed

(iv) Double winder, to determine muscle endurance

The motivation for using these tests was so that four areas of fitness relevant to field hockey could be assessed, namely flexibility, muscle power, speed and muscle endurance. Furthermore, these four tests formed part of the normal testing protocol of players at a national level.

Fitness testing of South African national players was conducted under the auspices of South African hockey's Medical Committee. The researcher became familiar with the testing procedure by attending one of these fitness tests prior to performing the tests in this study.

Each test will now be discussed in further detail.

3.5.3.1 Flexibility (Sit and reach test)

This test was used to determine hamstring muscle flexibility. The flexibility of this particular muscle was measured for three reasons. Firstly, the nature of hockey requires that the player spends much of the time in a position of sustained lumbar and hip flexion (Fox 1981), which

requires adequate hamstring flexibility (Fox 1981). Secondly, the hamstring muscle spans across two joints, and because of this is thought to be more susceptible to injury (Bruckner and Khan 1993).Thirdly, anecdotal reports from coaches and players indicate that hamstring strains were common amongst hockey players.

The sit and reach test was chosen as the measure of hamstring flexibility in this study because it is a common clinical test and is easy to perform. Furthermore, it is the method utilised in testing the hamstring flexibility of national players and was also the method employed in a study of the anthropometric measurements of South African club players (Scott 1991). The sit and reach test has been shown to be a valid (Wells and Dillon 1952) and reliable (Jackson and Baker 1986, Allen 1988, Jackson 1989) measure of hamstring flexibility.

The test is performed with the subject in the long-sitting position, with their knees fully extended. The subjects feet are placed against the cross board of a specially constructed measuring box (Figure 3.27 in Appendix 5). The subject is then required to reach forward as far as possible. A detailed description of the instrumentation and testing procedure of the sit and reach test is outlined in Appendix 5. Each subject repeated the test three times in succession. The reading for each attempt was recorded onto the testing data sheet, in millimetres (mm). An average of the three scores would be entered onto a spreadsheet at a later date. A positive score was recorded if the subject reached beyond their toes and a negative score was indicated if the player failed to reach beyond their toes.

Whilst each individual subject was tested, the other subjects were encouraged to keep warm by moving about.

3.5.3.2 Muscle power (Standing broad jump)

The standing broad jump is one of the most widely accepted practical field tests of lower limb muscle power and has been shown to be a reliable and valid measurement (Cooper 1963). This test measures explosive muscle power, and has been frequently used by researchers when testing the morphological characteristics of field hockey players (Bale and McNaught Davis 1983, Reilly and Bretherton 1986, Scott 1991).

The standing broad jump entails a subject jumping as far forward as possible from a standing start. The player maintains their foot positioning on landing, and the distance from the starting line to the heel of the foot nearest the line is recorded. A more detailed description of the standing broad jump test is outlined in Appendix 6. Each subject repeated the test twice, with the results being recorded onto the testing data sheet. The average of the two results would be entered onto a spreadsheet at a later date.

3.5.3.3 Speed (40 m sprint)

The 40 m sprint test was used to measure the subjects running speed over a short distance. A sprint over such a distance stresses predominately the oxygen independent energy system, as well as the ATP-CP energy system (Hawley 1994). This particular distance was chosen because it is the distance tested in the South African national squad testing (Sharratt 1995). Such a distance is equivalent to almost half the length of a hockey field. It is not common for a player to sprint a greater distance than this during a game.

A description of the testing method is outlined in Appendix 7. Each subject completed the test twice and the time taken to complete the distance on each occasion was recorded onto the testing data sheet. The average of the two times was then recorded onto the spreadsheet.

### 3.5.3.4 Muscle endurance (Double winder)

The double winder test was used to measure muscle endurance. This test stresses the oxygen dependent energy system, as it involves exercise over a period of greater than 2 minutes (Hawley 1994). The motivation in choosing this test is that it is familiar to the majority of hockey players, is used regularly for fitness training, and is also the method of testing the endurance capacity of South African national players (Sharratt 1995).

A properly marked hockey field is used for the testing. Subjects perform this test as a group, and are required to carry their hockey sticks for the duration of the test. They begin at the base-line and run to the 25m line, 50m line, 75m line and 100m line respectively, returning to the baseline after each. They then repeat the test, but in reverse. Thus, on returning to the base-line from the 100m line, they run back to the 100m mark and work their way back via the 75m, 50m and 25m lines respectively. This is referred to as a winder. On crossing the baseline after their second run to the 25m line, their times are taken by a stopwatch. Subjects get a 4 minute rest, and then repeat the testing procedure. The times (in seconds) for both the first and second winder are recorded onto the testing data sheet. A more detailed description and graphic representation of the testing procedure is provided in Appendix 8 (Figure 3.28).

In summary, the first part of the study was completed prior to the start of the hockey season (and thus before the start of part two of the study). It consisted of a questionnaire completed by the subjects, and their subsequent participation in a pre-season fitness assessment, comprising four individual tests, namely the sit and reach test, standing broad jump, 40 m sprint and double winder.

## Part II: The epidemiology of field hockey injuries

### 3.5.4.1 Injury documentation

The second part of the study was a prospective cohort study documenting the incidence of field hockey injuries in male and female players over the duration of the one playing season (1995).

For the purposes of this study an injury sustained during field hockey was defined as being physical damage which resulted in any one of the following:

- a player being unable to complete a match or practice
- a player missing a match or practice
- a player requiring medical attention

The motivation for this specific definition was to ensure that only those injuries which have a significant bearing on the player or game, in terms of time off hockey or the requirement of medical attention, were recorded. Minor injuries such as blisters or abrasions, which are of little long term consequence, were thus excluded from the study.

During Part I of the study, the players were informed as to what constituted an injury and were asked to inform their coach should they sustain an injury during the season. A potential under-reporting of injuries by players, for fear of losing their place in the team, was possible. This was largely negated by the fact that the coaches themselves would be able to identify an injury that resulted in a player being unable to complete, or missing, a match or practice. The coach would only rely on the players feedback for an injury that required them to seek medical attention.

#### 3.5.4.2 Data Collection

The coaches were required to retain a list of those players injured each week for the duration of the season. A roster was established so that each coach was contacted by telephone by the researcher on a particular day each week to obtain the list of injured players in that team. The injured players were then contacted by the researcher and an injury report form for each player was completed over the telephone (Appendix 3).

The coaches were also required to keep an attendance register on a weekly basis to record whether any player in the study population failed to attend a match or practice. These data were supplied by the coach to the researcher each week. Thus a record was established of the number of hours each subject played over the duration of the season (total, matches, practices). This information would later be used to calculate the incidence of injury (number of injuries per 1000 hours of play).

The injury report form (Appendix 3) recorded information on the name, club, position, and date of injury of the injured player. It was noted whether the injury was sustained at a match or practice. The anatomical site, type and mechanism of injury were recorded, and whether the injury occurred on grass or artificial turf. The player was questioned as to whether they completed that particular match or practice and whether they missed subsequent matches or practices.

Players who missed a match or practice due to injury were monitored on a weekly basis until they returned to hockey in order to ascertain the number of matches and practices that they missed because of the injury.

The injured players were asked if they sought medical attention for their injury, and if so, which medical professional they consulted, and whether any further investigation or procedure was conducted. All the data were entered onto the injury report form by the researcher.

## 3.6 Assumptions

A number of assumptions with regards to the study population were made by the researcher:

(i) that each coach maintained an accurate register of players attendance at both matches and practices

(ii) that each coach reported all the injuries sustained by their players throughout the season

(iii) that all the players who sought medical attention informed either the coach or researcher

(iv) that each teams coach was present at every match and practice, and if not, the responsibilities of the coach, in terms of recording player attendance and reporting of injuries, was undertaken by one of the players.

## 3.7 Bias

Bias can enter into a study in a number of ways. The bias inherent in population selection was eliminated as the entire population of first league players were included in the study population. The potential for inter-observer bias in both the questionnaire application and pre-season fitness assessment, as well as the injury documentation, was minimised because only the researcher was responsible for the administration of both Part I and Part II of the study. The potential for intra-observer bias existed in that it was the researcher herself that was responsible for the testing, as opposed to a neutral party.

## 3.8 Limitations of the study

The study was limited in that it was only possible to do telephonic interviews for the documentation of injury, as opposed to actual medical assessment of the injury. This had to be done because it was not possible for the researcher to individually assess each injured subject, due to time constraints. As a result only the anatomical site and type of injury as opposed to a specific clinical diagnosis could be documented. The diagnosis of the injury was thus based on the injury history and not an actual clinical examination.

## 3.9 Statistical analysis

Data from the player profile questionnaire, pre-season fitness assessment, attendance sheet and injury report form were entered into a spreadsheet supplied by the Biostatistics Department of the Medical Research Council (MRC). This spread sheet was drawn up in consultation with a statistician. Data was entered by the researcher. It was then analysed by the Biostatistics Department of the MRC.

Chi-square tests were the statistical test most commonly employed when comparing two variables, although Fishers exact test was used if chi-square was invalid due to a small cell count. The non-parametric Wilcoxon test was used when comparing fitness test results with a specific injury, as well as participation in pre-season training. Correlational analysis (Spearmans correlation coefficients) was used when comparing age and site of injury, and to establish whether any correlations existed between any of the fitness variables. Prior to the analysis a 0.05 level of statistical significance was established.

# Chapter Four

# RESULTS

**Contents**

## Part I: Player profile questionnaire and pre-season fitness assessment

### 3.1 Player profile questionnaire

#### 3.1.1 Characteristics of the sample population

The sample population comprised of 222 first league hockey players, with equal numbers of male (n=111) and female (n=111) players. The ages of the sample ranged from 17 to 48 years. The mean age for the whole sample was 24.4 ± 5 years, with the female players (25.3±6 years) being slightly older than their male counterparts (23.5±4 years). On dividing the players into four age categories, the 20-24 year olds were the largest group (n=101; 45%), followed by the 25-29 (n=59; 27%), and the youngest (<20 years) (n=31; 14%) and oldest categories( >30 years) (n=31; 14%). Players were categorised into four playing positions, namely strikers (n=69; 31%), midfielders (n=73; 33%), defenders (n=72; 32%) and goalkeepers (n=18; 4%).

#### 3.1.2 Seasonal incidence of injury (retrospective analysis)

The retrospective study by questionnaire of the injuries sustained in the previous season (1994), recorded a total of 116 injuries. The true incidence of injury (injuries/1000 hours of play) could not be measured in the retrospective study because the number of playing hours were not recorded. The seasonal frequency of injury in male and female players, as well as for specific anatomical regions, is depicted in Table 3.1. Male players sustained 43% (n=50) of the injuries, whilst female players sustained 57% (n=66) of the injuries. Female players sustained the most injuries to the head (n=9), upper (n=9) and lower (n=42) limbs, with male players sustaining the most injuries to the pelvic area (n=8). There was no significant difference between the frequency of injuries sustained by either gender at any of the four anatomical regions (head p=0.789; upper limb p=0.153; pelvis/back p=0.391; lower limb p=0.135).

Table 3.1 Anatomical sites of field hockey injuries in the total population, male and female players (1994 retrospective study)

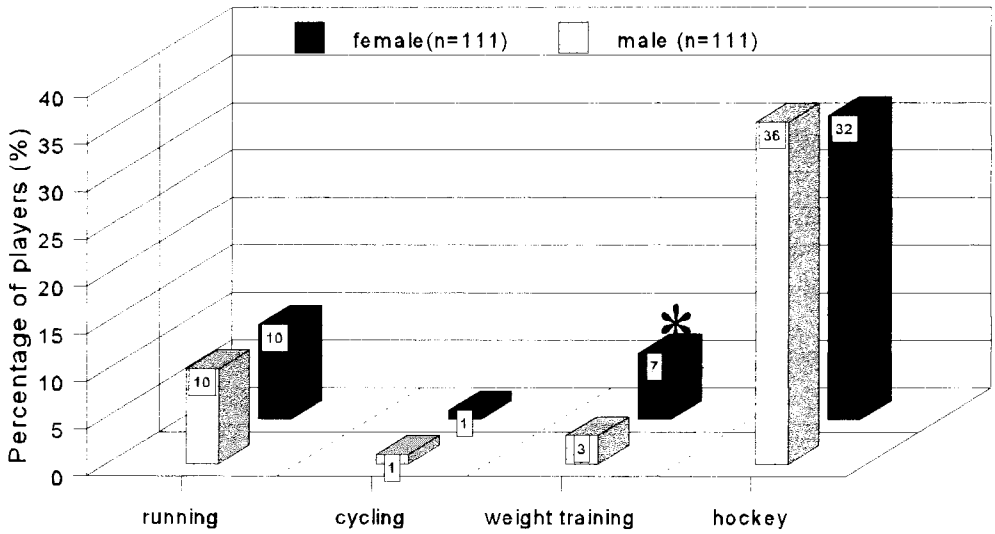
| | **Male** | **Female** | **Total** |
|---|---|---|---|
| **1.Head** | **7/116 (6%)** | **9/116 (8%)** | **16/116 (14%)** |
| head | 3 | 1 | 4 |
| eyes | 0 | 5 | 5 |
| nose | 2 | 0 | 2 |
| mouth | 1 | 2 | 3 |
| jaw | 0 | 1 | 1 |
| neck | 1 | 0 | 1 |
| **2.Upper Limb** | **5/116 (4%)** | **9/116 (8%)** | **14/116 (12%)** |
| shoulder | 1 | 0 | 1 |
| elbow | 0 | 0 | 0 |
| wrist | 2 | 2 | 4 |
| fingers | 2 | 7* | 9 |
| **3.Pelvis, back** | **8/116 (7%)** | **6/116 (5%)** | **14/116 (12%)** |
| back | 4 | 2 | 6 |
| groin | 4 | 4 | 8 |
| hip | 0 | 0 | 0 |
| **4.Lower limb** | **30/116 (26%)** | **42/116 (36%)** | **72/116 (62%)** |
| quadriceps | 2 | 2 | 4 |
| hamstrings | 10 | 12 | 22 |
| knee | 4 | 7 | 11 |
| calf | 1 | 2 | 3 |
| anterior lower leg | 1 | 5 | 6 |
| ankle | 7 | 8 | 15 |
| Achilles tendon | 4 | 5 | 9 |
| foot | 1 | 1 | 2 |
| **TOTAL** | **50** | **66** | **116** |

*: p=0.089 (male versus female)

### 3.1.3 Training Methods

#### 3.1.3.1 Pre-season Training

One hundred and eighty one (81.5%) of the players performed pre-season training. The type of training that players performed is depicted in Figure 3.1, and included running, cycling, weight training and summer league hockey. Significantly more female players performed weight training compared with male players (p=0.025).




* : p<0.05 (male versus female)

Figure 3.1 The percentage (%) of male and female hockey players participating in pre-season training

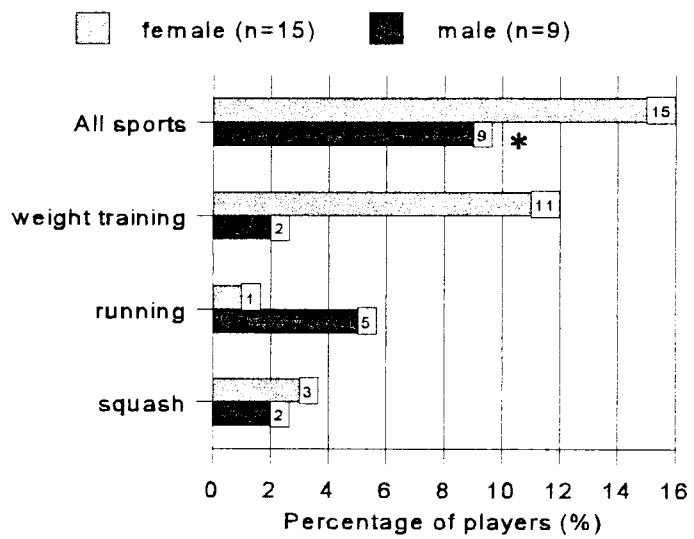
The frequency of participation in a specific type of pre-season training within any of the playing positions is depicted in Table 3.2. There was no significant difference in the frequency of pre-season training between player positions.

Table 3.2 The percentage of players in each position participating in the various types of pre-season training, including the level of significance (p)

| | **Running** | **Cycling** | **Weight training** | **Hockey (summer league)** |
|---|---|---|---|---|
| **Striker** | 26% | 3% | 13% | 75% |
| **Midfielder** | 21% | 1% | 7% | 63% |
| **Defender** | 19% | 0% | 8% | 61% |
| **Goalkeeper** | 1% | 1% | 1% | 83% |
| **p** | 0.269 | 0.356 | 0.738 | 0.140 |

3.1.3.2 Participation in other sports during the hockey season.

Hockey players reported participation in other sports during the winter hockey season in only three sports. Twenty-four players (10.8%) participated in these other sports during the winter season. They consisted of running (n=6), weight training (n=13) and squash (n=5). Significantly more females (n=15) participated in other sports during the winter hockey season compared to male players (n=9) (p=0.012) (Figure 3.2).




*p<0.05 (male versus female)

Figure 3.2 Male and female players (%) participating in sports other than hockey

3.1.3.3 Stretching protocol

The majority of subjects (n=221; 99.5%) incorporated stretching into their warm-up routine. The details of the stretching routine employed by players was assessed with respect to the timing of the stretching, duration of stretching and whether or not the stretch was repeated. All the players who stretched did so before playing (n=221; 100%), and almost half that number (n=90; 41%) after play. Only a single player stretched during play. All 221 players indicated that they maintained a stretch for less than 20 seconds. The most frequently reported duration of stretch was between six and ten seconds (n=111; 50%), followed by 11 to 15 seconds (n=74; 33%) (Figure 3.3).

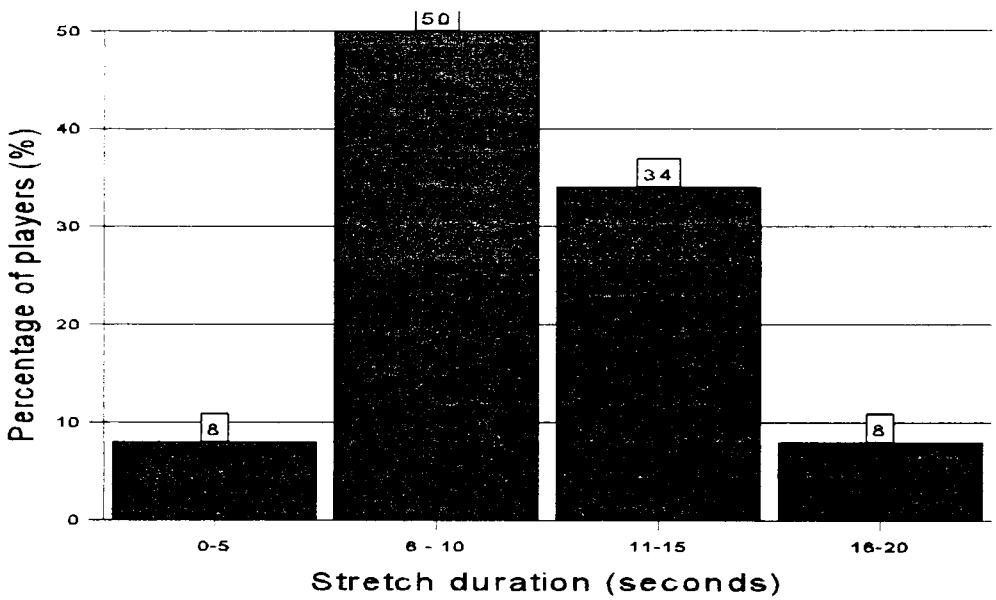



Figure 3.3 Reported duration of stretch (in 5 second groupings) by field hockey players (n=221)

No player indicated that they repeated a stretch more than four times, with the most common number of repetitions being two (n=114; 52%), followed by three (n=84; 38%) (Figure 3.4)

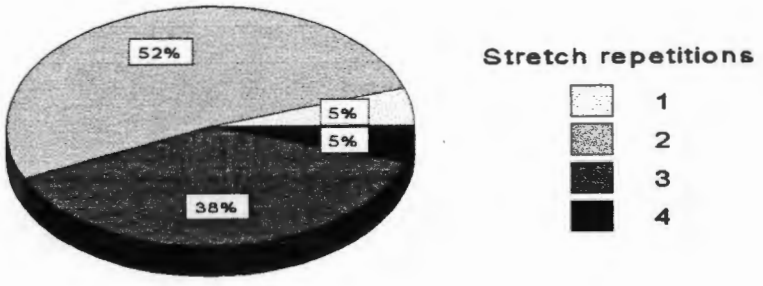



Figure 3.4 The percentage of hockey players (%) that employed a particular stretch repetition

### 3.1.4 Equipment used by hockey players

#### 3.1.4.1 Mouth protector

The majority (n=123; 55.4%) of players indicated that they did not wear a mouth protector. Of the 99 players who wore a mouth protector, 47% were male and 53% female (Table 3.3). There was no significant difference in the frequency of use of mouth protectors between males and females. The 99 players that did wear a mouth protector did so either at both matches and practices (39%), or just during matches (61%), but never at practices alone.

Table 3.3 The frequency of use (%) of a mouth protector by male and female players

| | **Total** | **Male** | **Female** |
|---|---|---|---|
| **Yes** | 99 | 47 (47%) | 52 (53%) |
| **No** | 123 | 64 (52%) | 59 (48%) |

3.1.4.2 Footwear

Two hundred and twelve hockey players (95.5%) wore hockey boots, with only a small percentage (4.5%) choosing to wear either cross trainers/ running shoes. The type of hockey boot that players wore is depicted in Figure 3.5. The most frequently worn brand of boot was Patrick (n=114; 54%), followed by Olympic (n=24; 11%) and Adidas (n=19; 9%) (Figure 3.5).The most popular specific model of boot was the Patrick Bioturf (n=67; 31.6%), followed by Patrick Advance (n=38; 17.9%).

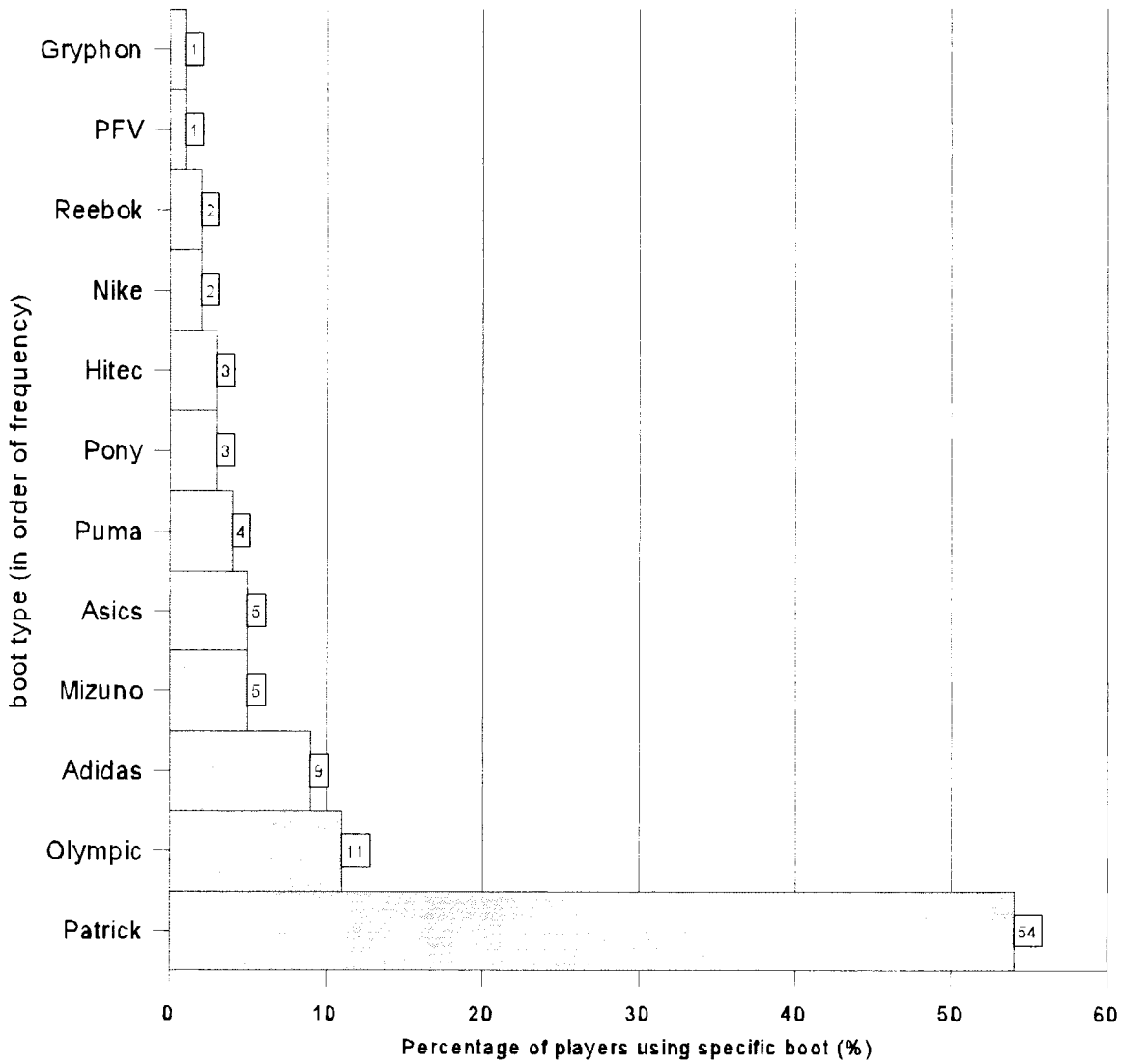



Figure 3.5 The percentage (%) of specific brands of hockey boots worn by field hockey players

3.3 External support and protective devices

A variety of protective and supportive devices were used by the subjects, and included finger, knee, shin and ankle guards, as well as orthotics and corsets (Figure 3.6). The most frequently used item was shinguards, which were worn by the majority of players (n=214; 96%).

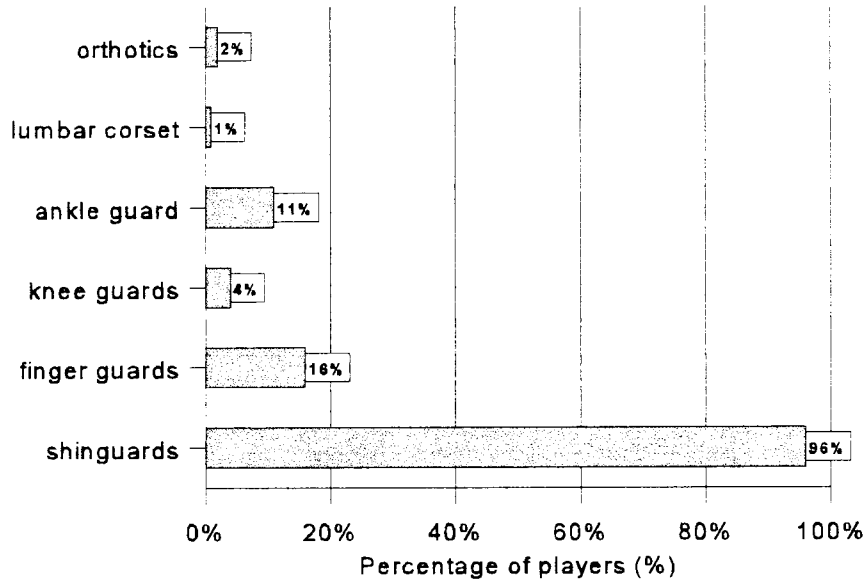
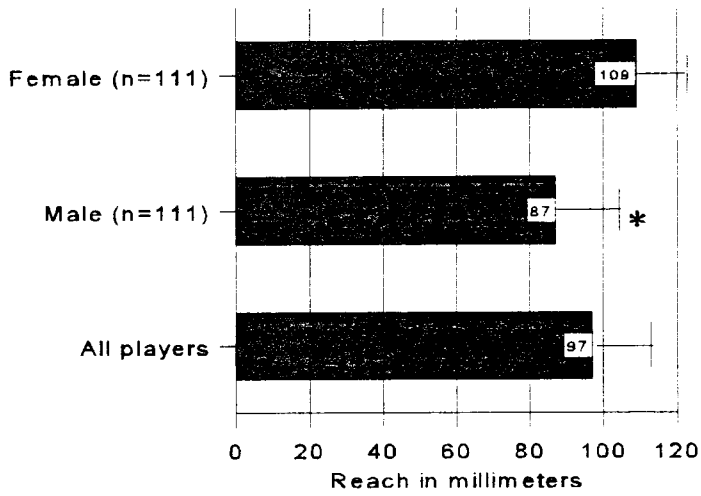



Figure 3.6 The percentage of players (%) using external support and protective devices

## 3.2 Pre-season fitness assessment

### 3.2.1 Flexibility (Sit and reach test)

Flexibility of the hamstring muscle was measured using the sit and reach test. As shown in Figure 3.7, the total reach (mm) (mean±SD) of the population was 97±17 mm, with females (109±18 mm) stretching significantly further than males (87±16 mm) (p=0.012).




*: $p<0.05$ (male versus female)

Figure 3.7 The sit and reach test (mm) (mean±SD) in the total population, male and female players

The results of the sit and reach flexibility test (mm) for the different age categories is depicted in Figure 3.8. Of the four age categories, the 20-24 year old players achieved the longest reach (111±17mm). There was no significant difference between the age groups.

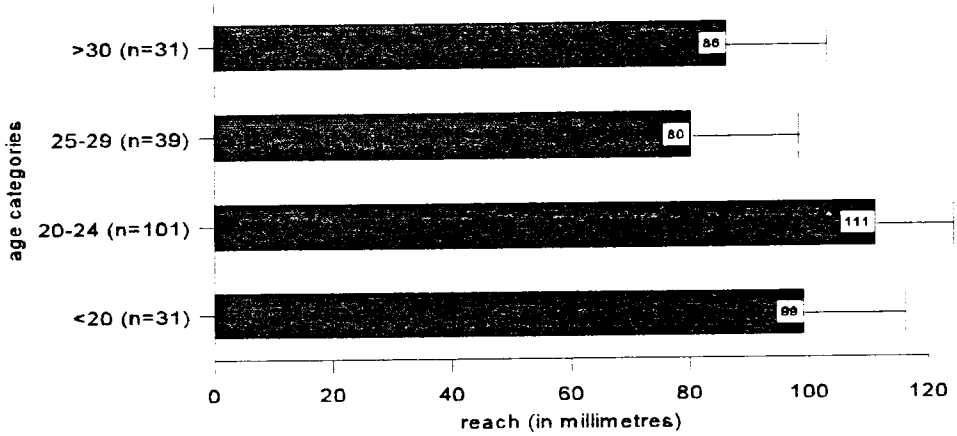



Figure 3.8 The sit and reach test (mm)(mean±SD) for the four age categories of players

The sit and reach results of the four playing positions is depicted in Figure 3.9. Goalkeepers stretched the furthest (114±19mm) (Figure 3.9). There was no significant difference between the sit and reach test results of attacking (strikers/midfielders) and defending (defenders, goalkeepers) players (p=0.8975).

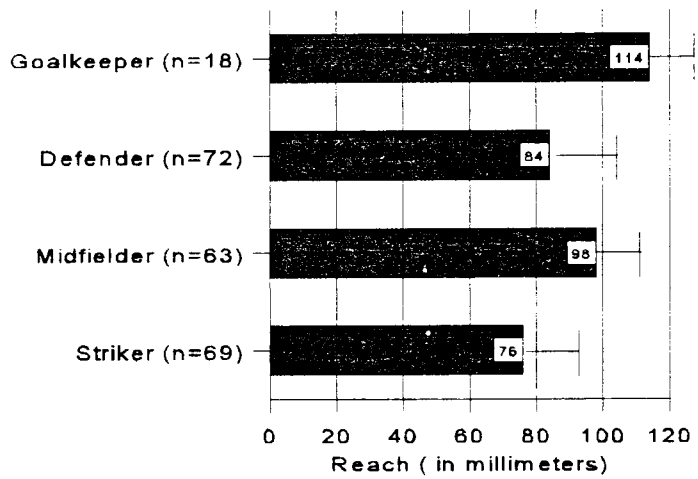



Figure 3.9 The sit and reach test (mm)(mean±SD) for the four playing positions

There was no significant difference between the number of times a player repeated a stretch and their sit and reach results (p=0.579) (Table 3.4). However, as depicted in Table 3.5, there was a significant correlation between the length of time a stretch was maintained for and sit and reach results, with those players who maintained their stretch position for longer than ten

seconds achieving significantly better scores than those players maintaining the stretched position for shorter than ten seconds (p=0.0001).

Table 3.4 The relationship between stretch repetition and sit and reach results

| | Two or less repetitions | Three or more repetitions |
|---|---|---|
| n | 126 | 96 |
| Mean score | 109.4 | 114.2 |

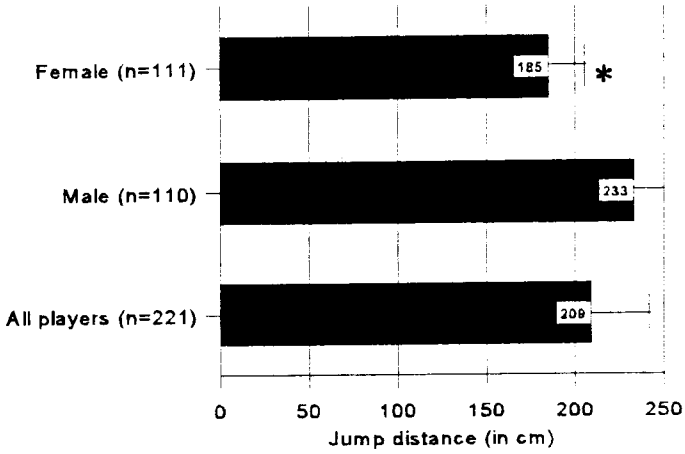
Table 3.5 The relationship between the duration of stretch (seconds) and sit and reach results

| | Stretch duration (10 sec or less) | Stretch duration (longer than 10 sec) |
|---|---|---|
| n | 130 | 92 |
| Mean score | 91.6 | 139.7* |

*: $p<0.05$

### 3.2.2 Muscle Power (Standing broad jump)

Leg muscle power was measured using the standing broad jump. The length of jump (cm) (mean±SD) achieved by the entire population was 209±31 cm (Figure 3.10). Male players (233±18 cm) had a significantly further jump than female players (185±21 cm) (p=0.0001), as depicted in Figure 3.10. There was no significant difference between the age groups (p=0.3517), with the 25-29 year old players achieving the longest jumps (Figure 3.11). There was no significant difference between the jump distance of the various playing positions, with the midfielders jumping furthest (213±33 cm) (Figure 3.12). However, attack-orientated players (strikers, midfielders) (212±30 cm) had a marginally significantly further jump distance than defence-orientated players (defenders, goalkeepers) (203±29 cm) (p=0.0704).




*: $p<0.05$ (male versus female)

Figure 3.10 Standing broad jump (cm)(mean±SD) for the total population, male and female hockey players

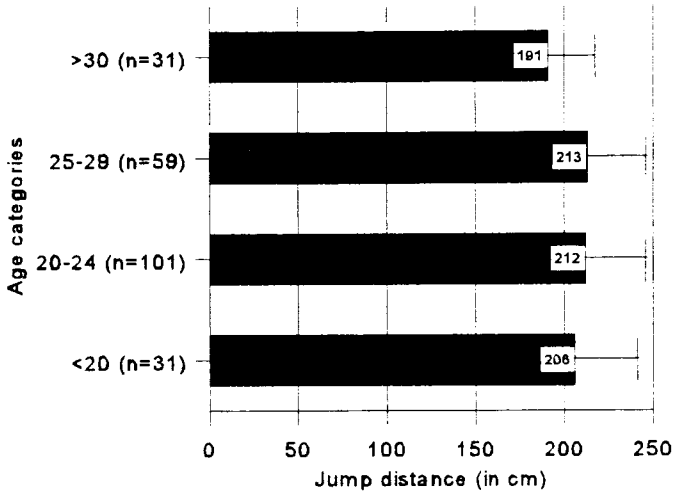



Figure 3.11 Standing broad jump (cm)(mean±SD) for the four age categories of players

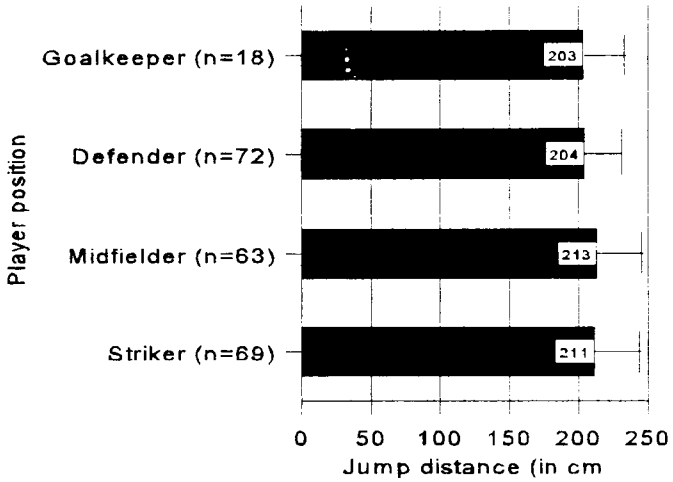
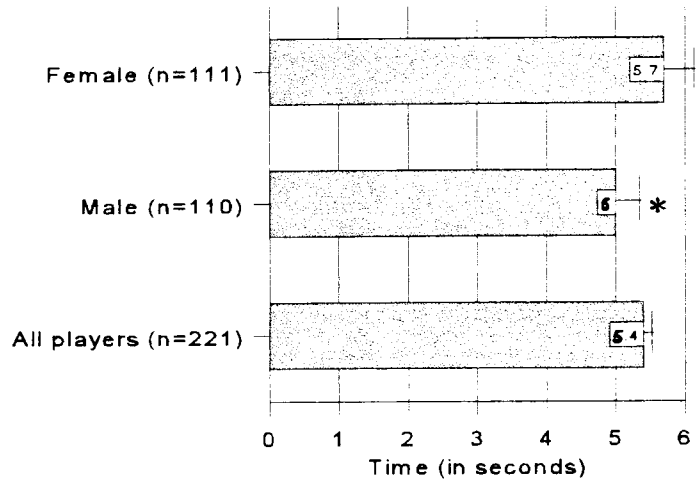



Figure 3.12 Standing broad jump (cm)(mean±SD) for the four playing positions

### 3.2.3 Speed (40 m sprint)

Sprint speed was measured over a 40 m distance. The speed (sec) (mean±SD) achieved by the total population was 5.4±0.5 seconds (Figure 3.13), with males (5.0±0.3 sec) being significantly faster than females (5.7±0.4 sec) over this distance (p=0.0001).




*: $p<0.05$ (male versus female)

Figure 3.13 Forty metre sprint times (sec) for the total population, male and female players

There was no significant difference between the times attained by the various age categories (p=0.9471) (Figure 3.14) or by the four playing positions (Figure 3.15). However, the 25-29 year old players achieved the fastest times (5.2±0.4 sec), and attack-orientated players (strikers, midfielders) (5.2±0.4 sec) had significantly faster times than defence-orientated players (defenders, goalkeepers) (5.6±0.5 sec) (p=0.0003).

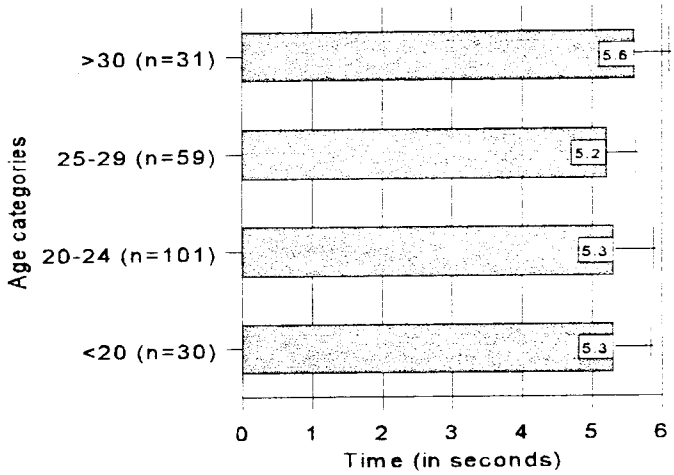



Figure 3.14 Forty metre sprint time (sec)(mean±SD) for the four age categories

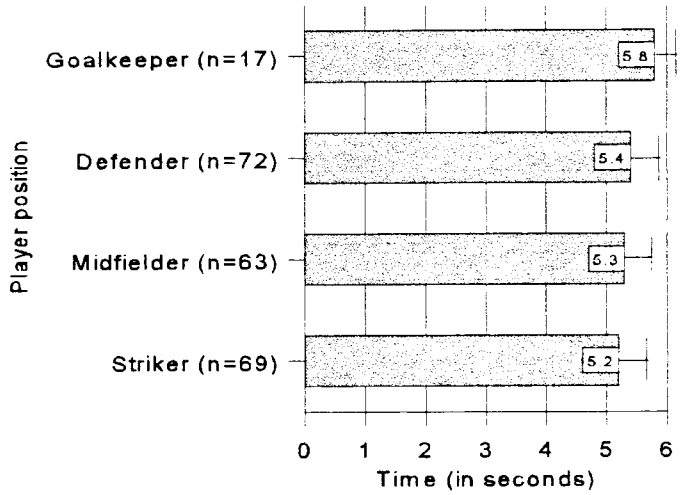
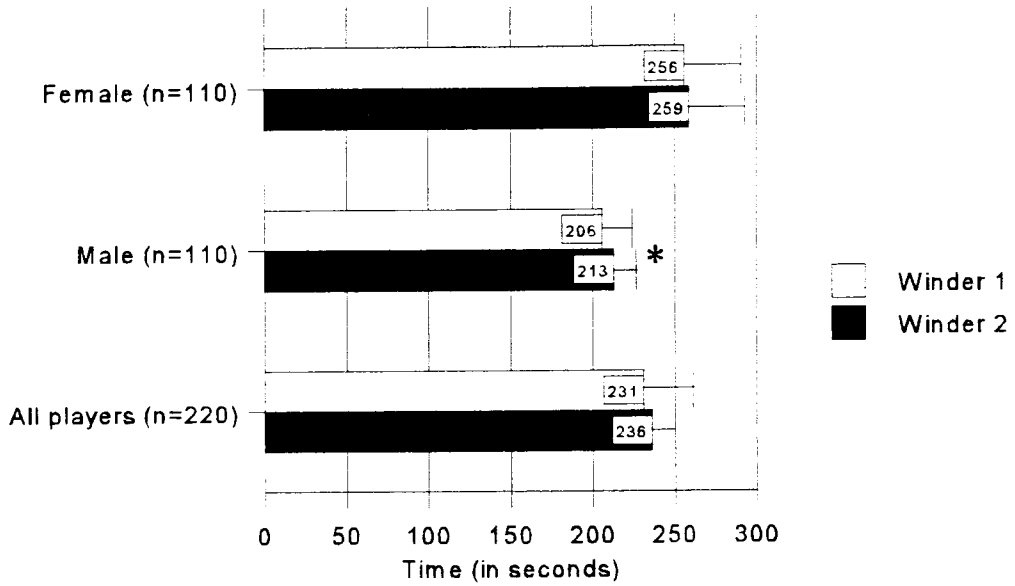



Figure 3.15 Forty metre sprint time (sec)(mean±SD) for the four playing positions

### 3.2.4 Muscle Endurance (double winder)

Muscle endurance was determined using the double winder test. The mean time (sec) (mean±SD) in the population for the first winder was 231 ± 33 seconds, and the second winder was 236 ± 34 seconds (Figure 3.16). Male players were significantly faster than the females in both winders (p=0.0001).




*p<0.05 (male versus female)

Figure 3.16 Double winder times (sec)(mean±SD) for the total population, male and female hockey players

The double winder test results for the four different age categories is depicted in Figure 3.17. There was no significant difference between the double winder times of the four age groups (p=0.3271) (Figure 3.17).

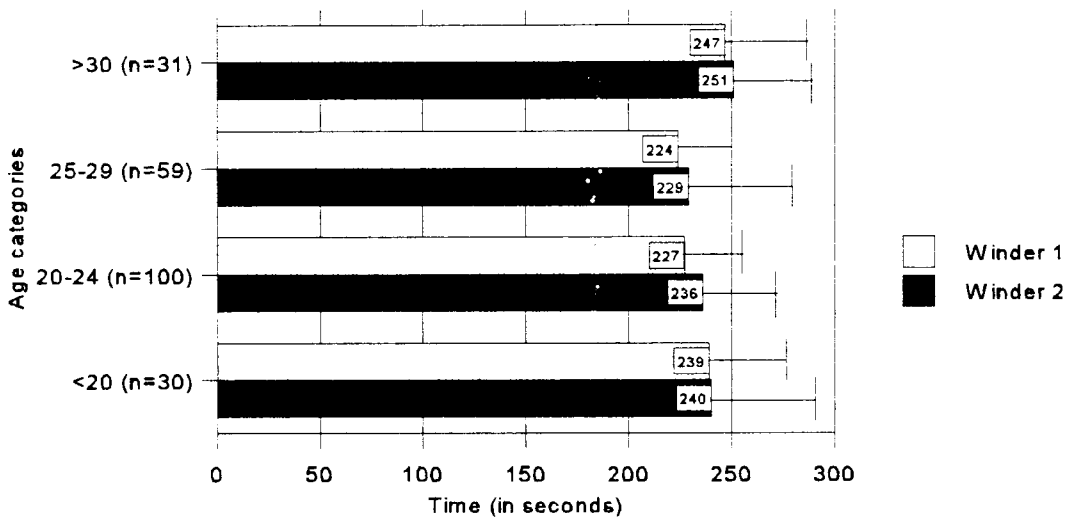



Figure 3.17 Double winder times (sec) for the four age categories of hockey players

The double winder test result for the four different player positions is depicted in Figure 3.18. There was no significant difference in the time taken to complete the double winder (sec)

between the four positions, although the attacking players finished significantly quicker than the defending players (p=0.002).The position which achieved the fastest times in both winders were the midfielders (222±28 sec and 227±27 sec) (Figure 3.18).

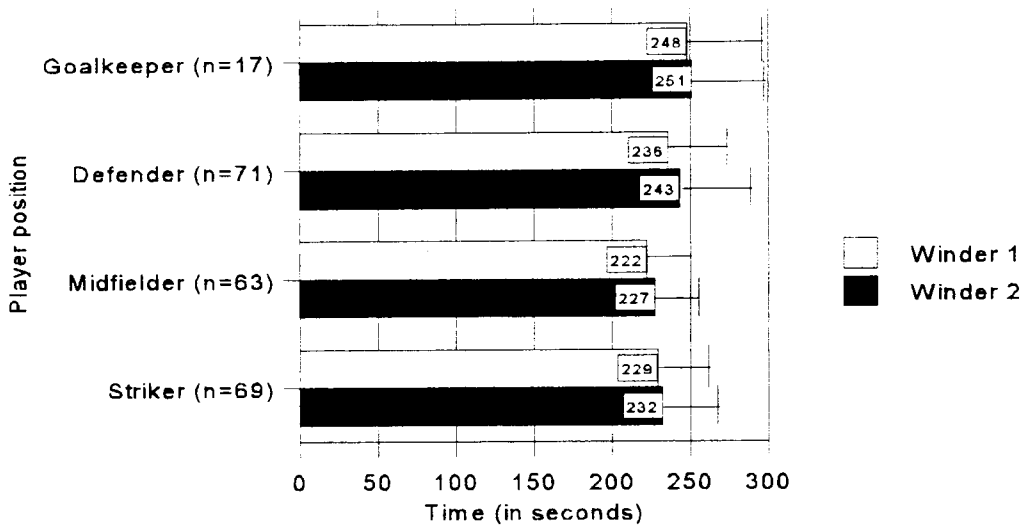



Figure 3.18 Double winder times (sec)(mean±SD) for the four playing positions

Summaries of all four fitness test results for male and female players, the four age categories and all the playing positions are depicted in Table 3.6, Table 3.7 and Table 3.8 respectively.

Table 3.6 Summary of all four fitness test results (mean±SD)for male and female hockey players

| | **Sit and Reach (mm)** | **Broad jump (cm)** | **40 m Sprint (sec)** | **Winder 1 (sec)** | **Winder 2 (sec)** |
|---|---|---|---|---|---|
| **male** | 87 ± 16 | 232.6* ± 18.4 | 5.0*± 0.3 | 206± 14* | 213 ± 19* |
| **female** | 109* ± 18 | 185.0 ± 21.0 | 5.7 ± 0.4 | 256± 28 | 259 ± 29 |

*: $p<0.05$ (male versus female)

Table 3.7 Summary of all four fitness test results (mean±SD) for each of the four age categories

| | **Sit and Reach (mm)** | **Broad jump (cm)** | **40 m Sprint (sec)** | **Winder 1 (sec)** | **Winder 2 (sec)** |
|---|---|---|---|---|---|
| **<20** | 99 ± 17 | 206 ± 29 | 5.3 ± 0.5 | 240± 47 | 239 ± 38 |
| **20-24** | 111 ± 17 | 212 ± 33 | 5.3 ± 0.5 | 227± 31 | 236± 34 |
| **25-29** | 80 ± 19 | 213 ± 29 | 5.2 ± 0.4 | 224± 26 | 229 ± 28 |
| **>30** | 86 ± 16 | 191 ± 26 | 5.6 ± 0.5 | 247± 32 | 251 ± 32 |

Table 3.8 Summary of all four fitness test results (mean±SD) for each playing position

| | **Sit and Reach (mm)** | **Broad jump (cm)** | **40 m Sprint (sec)** | **Winder 1 (sec)** | **Winder 2 (sec)** |
|---|---|---|---|---|---|
| **Striker** | 76 ± 17 | 211 ± 29 | 5.2 ± 0.4 | 229 ± 35 | 232 ± 29 |
| **Midfielder** | 98 ± 17 | 213 ± 33 | 5.3 ± 0.4 | 222 ± 28 | 227 ± 27 |
| **Defender** | 84 ± 18 | 204 ± 31 | 5.4 ±0.5 | 236 ± 32 | 243 ± 37 |
| **Goalkeeper** | 114 ±19 | 203 ± 30 | 5.8 ± 0.6 | 248 ± 41 | 251 ± 44 |

**Part II: <u>The epidemiology of field hockey injuries</u>** (Prospective study)

In this section the overall incidence of injury, as well as the incidence in different ages, genders and players positions will be presented. The injury data will also be presented in terms of date of injury during the season, whether it was during a match or practice, anatomical site of injury, type and mechanism of injury and consequences of the injury (whether or not the injury required treatment, and if the injury resulted in that player missing subsequent hockey sessions). The influence of playing surface in injury risk and incidence will also be reported.

### 3.3.1 The overall number, incidence and risk of injury

In the 1995 hockey season a total of 132 injuries were recorded in the sample population (n=222). A total of 13183 playing hours (matches and practices) were recorded during the season. This resulted in an overall incidence of injury (IOI) of 10 injuries/1000 playing hours, with an injury risk of 0.59 injuries per player per season (Table 3.9).

Table 3.9 The total number of injuries, playing hours, incidence of injury (injury/1000 hours) and injury risk for the total population of hockey players

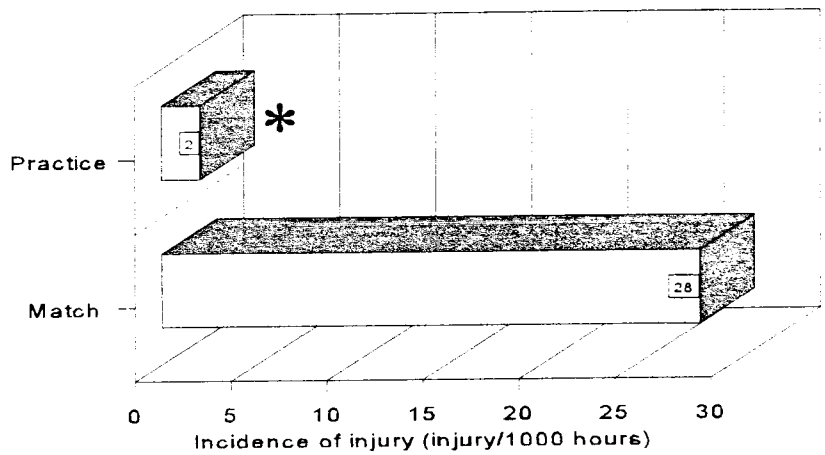
| **N** | **Total injuries** | **Total playing hours (hrs)** | **Incidence (inj/1000hrs)** | **Injury risk per player** |
|---|---|---|---|---|
| 222 | 132 | 13182 | 10 | 0.59 |

### 3.3.2 Match versus practice

The majority of the injuries occurred during matches (n=111; 84%), the remainder occurring during practice (n=21; 16%) (Table 3.10).The incidence of injury (injuries/1000 hrs) is depicted in Figure 3.19. There was a significantly lower incidence of injury in practices compared with matches (p=0.003).

Table 3.10 Match and practice injuries, hours of play and injury risk for the total population of hockey players

| | **Injuries** | **Hours played** | **injury risk per player** |
|---|---|---|---|
| **match** | 111 | 3938 | 0.50 |
| **practice** | 21 | 9245 | 0.09 |




*p<0.05 (match versus practice)

Figure 3.19 The incidence of injury (injury/1000 hours) in matches and practices

### 3.3.3 Gender

Male players sustained a slightly greater number of injuries (n=72; 55%), when compared to their female counterparts (n=60; 45%), but this was not significantly different. The incidence of injury for males was 11 injuries /1000 playing hours, and females 9 injuries/1000 hours (Table 3.11). There was no significant difference between incidence of injury, site of injury, type of injury or mechanism of injury between male and female players.

Table 3.11 The number and incidence of injury (injuries/1000 hours) of male and female players

| | **N** | **number of injuries** | **Incidence** |
|---|---|---|---|
| **male** | 111 | 72 | 11/1000hrs |
| **female** | 111 | 60 | 9/1000hrs |

The anatomical site (n) of injuries in male and female hockey players for the 1994 (retrospective) and 1995 (prospective) season are depicted in Table 3.12. In the 1994 (retrospective) season, female players were injured more frequently (n=66) than male players (n=50), whereas it was the male players that were more frequently injured (n=72) than the females (n=60) in the 1995 (prospective) season. However, neither of these findings were statistically significant.

Table 3.12 The total number (n) and percentage (%) of all injuries, at all the anatomical injury sites and regions for the total population in 1994 and 1995

| | **1994 (retrospective) study** | | | **1995 (prospective) study** | | |
|---|---|---|---|---|---|---|
| **Site** | **Male** (n=111) | **Female** (n=111) | **Total** (n=222) | **Male** (n=111) | **Female** (n=111) | **Total** (n=222) |
| **1. Head** | **7** | **9** | **16 (14%)** | **12** | **9** | **21(16%)** |
| Head | 3 | 1 | 4 | 3 | 4 | 7 |
| Eye | 0 | 5 | 5 | 4 | 3 | 7 |
| Nose | 2 | 0 | 2 | 1 | 0 | 1 |
| Jaw | 0 | 1 | 1 | 2 | 1 | 3 |
| Mouth | 1 | 2 | 3 | 1 | 1 | 2 |
| Neck | 1 | 0 | 1 | 1 | 0 | 1 |
| **2. Upper limb** | **5** | **9** | **14 (12%)** | **15** | **17** | **32 (24%)** |
| Shoulder | 1 | 0 | 1 | 1 | 0 | 1 |
| Elbow | 0 | 0 | 0 | 1 | 1 | 2 |
| Wrist | 2 | 2 | 4 | 5 | 3 | 8 |
| Fingers | 2 | 7 | 9 | 8 | 13 | 21 |
| **3.Pelvis/back** | **8** | **6** | **14 (12%)** | **11** | **6** | **17 (13%)** |
| Back | 4 | 2 | 6 | 5 | 4 | 9 |
| Hip | 0 | 0 | 0 | 2 | 0 | 2 |
| Groin | 4 | 4 | 8 | 4 | 2 | 6 |
| **4. Lower limb** | **30** | **42** | **72 (62%)** | **34** | **28** | **62 (47%)** |
| Quadriceps | 2 | 2 | 4 | 0 | 0 | 0 |
| Hamstring | 10 | 12 | 22 | 6 | 5 | 11 |
| Knee | 4 | 7 | 11 | 10 | 8 | 18 |
| Anterior lower leg | 1 | 5 | 6 | 5 | 1 | 6 |
| Calf | 1 | 2 | 3 | 2 | 2 | 4 |
| Ankle | 7 | 8 | 15 | 8 | 10 | 18 |
| Achilles | 4 | 5 | 9 | 1 | 0 | 1 |
| Foot | 1 | 1 | 2 | 2 | 2 | 4 |
| **Total** | **50** | **66** | **116** | **72** | **60** | **132** |

3.3.4. Age

The incidence of injury (injuries/1000 hrs) in the different age categories is depicted in Figure 3.20. The 25-29 year old players had the highest incidence of injury (12 injuries/1000 hours) (Figure 3.20), but this was not statistically significant.

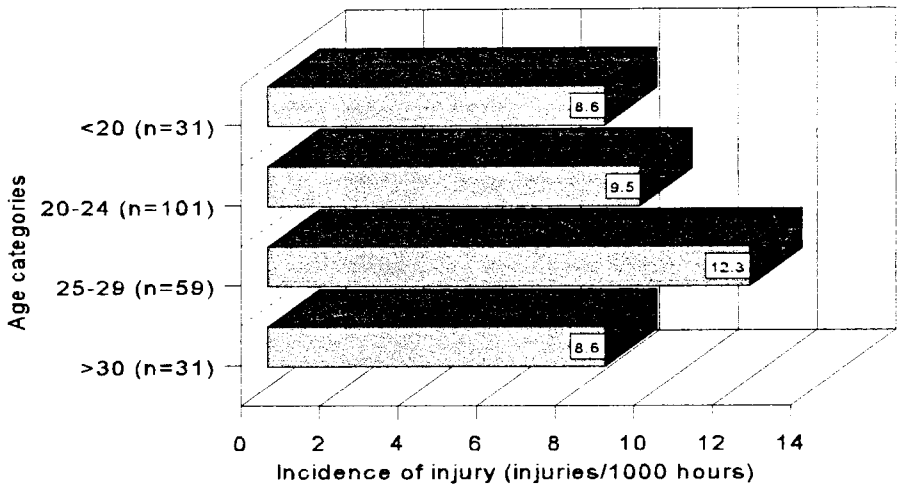



Figure 3.20 The incidence of injury (injuries/1000 hours) for the different age categories

Table 3.13 The frequency of injury (%) in different age categories

| Age category | Number of players | Injuries | % of category that were injured | % of total(222) |
|---|---|---|---|---|
| **<20** | 31 | 16 | 52% | 7% |
| **20-24** | 101 | 57 | 55% | 26% |
| **25-29** | 59 | 43 | 73% | 19% |
| **>30** | 31 | 16 | 52% | 7% |
| | | | **Total** | **59%** |

The number of injuries and the percentage of injuries (%) in each specific anatomical site in the four different age categories is depicted in Table 3.14.

Table 3.14 Injuries to anatomical sites for each age category for the prospective (1995) and retrospective (1994) studies.

| | <20 years | | 20-24 years | | 25-29 years | | >30 years | |
|---|---|---|---|---|---|---|---|---|
| | 1994 | **1995** | 1994 | **1995** | 1994 | **1995** | 1994 | **1995** |
| **1. Head** | 2 (13%) | **1 (4%)** | 7 (12%) | **7 (15%)** | 7 (16%) | **6 (22%)** | 5 (31%) | **2 (11%)** |
| head | | | 3 | 2 | 3 | 2 | 1 | |
| eye | 2 | 1 | 2 | 2 | 1 | 2 | 2 | |
| nose | | | | 1 | | | 1 | 1 |
| jaw | | | 1 | 1 | 2 | | | |
| mouth | | | | 1 | 1 | 1 | 1 | 1 |
| neck | | | 1 | | | 1 | | |
| **2. Upp. L** | 5 (31%) | **4 (16%)** | 13 (23%) | **7 (15%)** | 11 (26%) | **2 (8%)** | 3 (19%) | **1 (6%)** |
| shoulder | | 1 | | | 1 | | | |
| elbow | | | | | 1 | | 1 | |
| wrist | 1 | 1 | 3 | 3 | 4 | | | |
| fingers | 4 | 2 | 10 | 4 | 5 | 2 | 2 | 1 |
| **3. Pel/Lx** | 4 (25%) | **4 (16%)** | 4 (7%) | **6 (13%)** | 6 (14%) | **0** | 3 (19%) | **4 (22%)** |
| back | 1 | 3 | 3 | 2 | 4 | | 1 | 1 |
| hip | | | 1 | | | | 1 | |
| groin | **3** | **1** | | **4** | **2** | | **1** | **3** |
| **4. Low. L** | 5 (31%) | **16 (64%)** | 33 (58%) | **26 (57%)** | 19 (44%) | **19 (70%)** | 5 (31%) | **11 (61%)** |
| quadricep | | 1 | | 1 | | 1 | | 1 |
| hamstring | | 3 | 5 | 7 | 5 | 9 | 1 | 3 |
| knee | 2 | 3 | 8 | 4 | 7 | 4 | 1 | |
| AMLL | 1 | | 4 | 5 | | | 1 | 1 |
| calf | | 1 | 1 | | 2 | 2 | 1 | |
| ankle | 2 | 4 | 13 | 5 | 2 | 2 | 1 | 4 |
| achilles | | 3 | 1 | 4 | | | | 2 |
| foot | | 1 | 1 | | 3 | 1 | | |
| **TOTAL** | 16 | 25 | 57 | 46 | 43 | 27 | 16 | 18 |

Upp.L = upper limb
Pel/Lx = pelvis/lumbar
Low.L = lower limb
AMLL = anterior/medial lower leg

3.5. Time of Season

The studied period extended over 7 months of a hockey season (April-October). It was evident that the injuries peaked near the start of the season (month 2; n=44), and remained high after the mid season break (month 5; n=27) (Table 3.15). The highest incidence of injury (injuries/1000 hours) was reported in month 2 (16/1000 hours) (Figure 3.21).

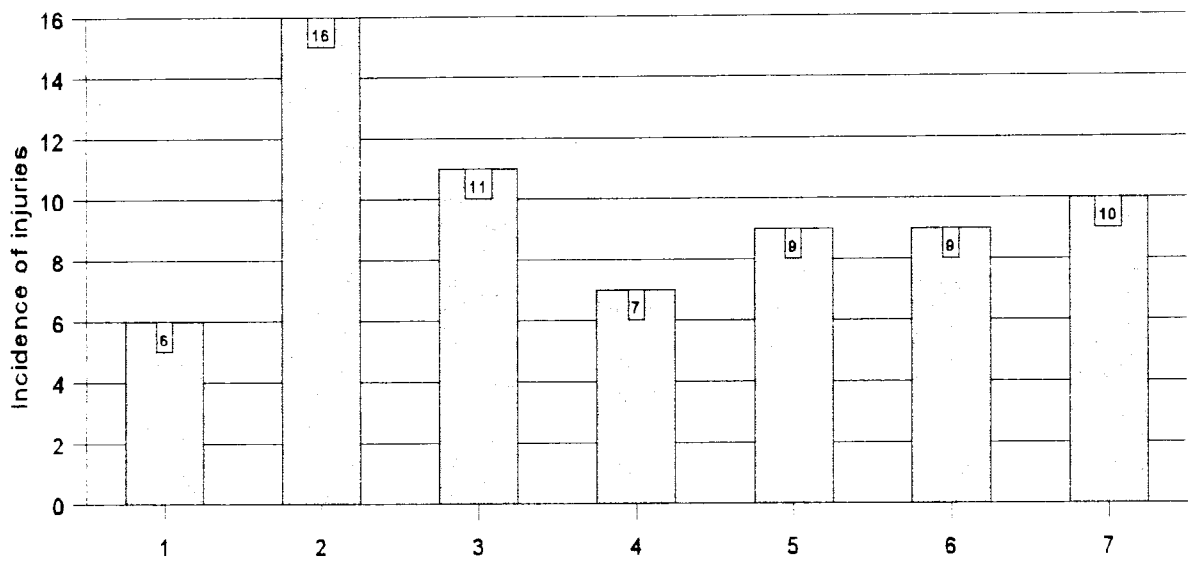



Figure 3.21 The incidence of injury (injuries/1000 hrs) for each month of the hockey season

The total number of injuries in each month, as well as the percentage of injuries (in brackets), that occurred in each anatomical site are depicted in Table 3.15. The greatest number of injuries to the upper limb, pelvic area and lower limb were sustained during the second month, with the greatest number of head injuries sustained in the 5 month. Injuries to the Achilles tendon and lower leg were only reported in the first three months of the season.

Table 3.15 The total number of injuries, as well as the percentage of injuries (in brackets), sustained at each anatomical site during each month (1-7) of the hockey season

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. Head | 3 (21%) | 5 (11%) | 1 (5%) | 3 (21%) | 6 (22%) | 3 (21%) | 0 |
| head | 1 | | | 2 | 3 | 1 | |
| eye | | 3 | | 1 | 1 | 2 | |
| nose | 1 | | | | | | |
| jaw | | 1 | 1 | | 1 | | |
| mouth | 1 | | | | 1 | | |
| neck | | 1 | | | | | |
| 2. Upper limb | 3 (21%) | 12 (27%) | 3 (17%) | 5 (36%) | 5 (19%) | 4 (29%) | 0 |
| shoulder | | | | | 1 | | |
| elbow | | | | | 1 | 1 | |
| wrist | | 3 | | 3 | 1 | 1 | |
| fingers | 3 | 9 | 3 | 2 | 2 | 2 | |
| 3. Pelvis/back | 1 (8%) | 6 (14%) | 2 (11%) | 2 (14%) | 5 (19%) | 1 (8%) | 0 |
| back | 1 | 3 | 1 | 1 | 2 | | |
| hip | | 1 | | | 1 | | |
| groin | | 2 | 1 | 1 | 2 | | |
| 4. Lower limb | 7 (50%) | 21 (48%) | 12 (67%) | 4 (29%) | 11 (40%) | 6 (42%) | 1 (100%) |
| quadriceps | | | | | | | |
| hamstrings | 1 | 4 | 1 | | 2 | 2 | 1 |
| knee | 1 | 7 | 5 | 2 | 1 | 2 | |
| ant/med lowL* | 1 | 2 | 3 | | | | |
| calf | | 1 | | 1 | 1 | 1 | |
| ankle | 3 | 6 | 1 | 1 | 6 | 1 | |
| achilles | | 1 | 2 | | | | |
| foot | 1 | | | | 1 | | |
| **TOTAL** | **14** | **44** | **18** | **14** | **27** | **14** | **1** |

*: anterior/medial lower leg

### 3.3.6 Player position

The number and incidence (injuries/1000 hrs) of injury for each player position is depicted in Table 3.16. There was no significant difference between the total incidence of injury of the various positions. Strikers had the greatest number of injuries (n=44; 33%), as well as the highest incidence (11 injuries/1000 playing hours) and seasonal incidence of injury (64%), whilst goalkeepers had the lowest number (n=8; 6%), incidence (8 injuries/ 1000 playing hours) and seasonal incidence (44%).

Table 3.16 The number and incidence (injuries/1000 hrs) of injuries, and risk of injury (%) for each playing position

| **Position** | **N** | **Number of injuries** | **Hours played (hrs)** | **Incidence (injuries/1000 hrs)** | **Seasonal injury risk (%)** |
|---|---|---|---|---|---|
| **striker** | 69 | 44 | 4097 | 11/1000 hrs | 64% |
| **midfield** | 63 | 38 | 3742 | 10/1000 hrs | 60% |
| **defence** | 72 | 42 | 4275 | 10/1000 hrs | 58% |
| **goalkeeper** | 18 | 8 | 1069 | 8/1000 hrs | 44% |

### 3.3.7. Anatomical site of injury

The four most common sites of injury were the fingers (n=21; 16%), knees (n=18; 14%) and ankles (n=18; 14%) and the hamstring muscles (n=11; 8%), as depicted in Table 3.17. On combining individual injury sites into injury regions, it was injuries to the lower limb (n=62; 47%) that predominated over the upper limb (n=32; 24%), head (n=21; 16%) and pelvic area (n=17; 13%). Significantly more upper limb injuries were sustained in the 1995 season, compared with the 1994 season (p=0.0076).

Table 3.17 The total number, percentage (in brackets) and incidence of all injuries to specific anatomical sites in the 1994 retrospective season and 1995 prospective season

| Site | Retrospective study (1994) | Prospective study (1995) | |
|---|---|---|---|
| | Number | Number | Incidence |
| **1. Head** | **16 (14%)** | **21(16%)** | **1.6** |
| Head | 4 | 7 | 0.5 |
| Eye | 5 | 7 | 0.5 |
| Nose | 2 | 0 | 0.1 |
| Jaw | 1 | 3 | 0.2 |
| Mouth | 3 | 2 | 0.2 |
| Neck | 1 | 1 | 0.1 |
| **2. Upper Limb** | **14 (12%)** | **32 (24%) *** | **3.2** |
| Shoulder | 1 | 1 | 0.1 |
| Elbow | 0 | 2 | 0.2 |
| Wrist | 4 | 8 | 0.6 |
| Fingers | 9 | 21* | 1.6 |
| **3.Pelvis, back** | **14 (12%)** | **17 (13%)** | **1.7** |
| Back | 6 | 9 | 0.7 |
| Hip | 0 | 2 | 0.2 |
| Groin | 8 | 6 | 0.5 |
| **4. Lower Limb** | **72 (62%)** | **62 (47%)** | **6.2** |
| Quadriceps | 4 | 0 | 0 |
| Hamstring | 22 | 11 | 0.8 |
| Knee | 11 | 18 | 1.4 |
| Anterior lower leg | 6 | 6 | 0.5 |
| Calf | 3 | 4 | 0.3 |
| Ankle | 15 | 18 | 1.4 |
| Achilles | 9 | 0 | 0.1 |
| Foot | 2 | 4 | 0.3 |

*$p<0.05$ (1994 versus 1995 season)

The incidence (injuries/1000 hours) of injury within each anatomical region for male and female players is depicted in Table 3.18. There was no significant difference between the incidence of injury in different anatomical regions in male and female players, although male players were more frequently injured in all but one region, namely the upper limb, where female players reported more injuries (Table 3.18).

Table 3.18 The incidence (injuries/1000 hours) of injuries to specific injury regions, sustained by male and female players

| **Region** | **Incidence of injury Male** | **Incidence of injury Female** |
|---|---|---|
| **1. Head** | 1.8 | 1.4 |
| **2. Upper limb** | 2.3 | 2.6 |
| **3. Pelvis/back** | 1.7 | 0.9 |
| **4. Lower limb** | 5.2 | 4.2 |

The incidence of injury in the four different age categories in each anatomical region is depicted in Table 3.19. There were no significant difference in the number or incidence of injury between the four age categories in each anatomical region. Players younger than 20 reported the highest incidence of injury pelvis/back (2.2/1000 hours) regions, while the 20-24 year old players had the highest incidence of injury in the lower limb (5.5/1000 hours). The 25-29 year old players reported the highest incidence of injury in the upper limb (3.1/1000 hours), and the players older than 30 reported the highest incidence of injury to the head (2.7/1000 hours).

Table 3.19 The incidence (injuries/1000 hours) of injuries to specific injury regions for each age category

| Region | <20 yrs | 20-24 yrs | 25-29 yrs | >30 yrs |
|---|---|---|---|---|
| 1. Head | 1.1 | 1.2 | 2.0 | 2.7 |
| 2. Upper limb | 2.7 | 2.2 | 3.1 | 1.6 |
| 3. Pelvis/back | 2.2 | 0.7 | 1.7 | 1.6 |
| 4. Lower limb | 2.7 | 5.5 | 5.4 | 2.7 |

The incidence of injury (injuries/1000 hrs) in different anatomical regions for each player position is depicted in Table 3.20. Outfield players (strikers, midfielders and defenders combined) sustained significantly more head ($p=0.043$) and lower limb ($p=0.025$) injuries compared to goalkeepers. However, goalkeepers sustained significantly more upper limb injuries than outfield players ($p= 0.001$) (Table 3.20).

Table 3.20 The incidence (injuries/1000 hours) of injuries to specific injury regions for each playing position

| Region | Striker | Midfielder | Defender | Goalkeeper |
|---|---|---|---|---|
| 1. Head | 1.9* | 1.6* | 1.4* | 0.9 |
| 2. Upper limb | 2.4 | 2.1 | 2.1 | 4.7^ |
| 3. Pelvis/back | 1.2 | 1.3 | 1.4 | 0.9 |
| 4. Lower limb | 5.1* | 5.1* | 4.9* | 0.9 |

*: $p<0.05$ (Outfield players versus goalkeepers)

^: $p<0.05$ (Goalkeepers versus outfield players)

### 3.3.8 Type of injury

The incidence of specific types of injury are depicted in Figure 3.22. The most common types of injury were strains (n=32; 2.4 injuries/1000 hours), sprains (n=27; 2.0 injuries/1000 hours) and fractures (n=22; 1.7 injuries/1000 hours).

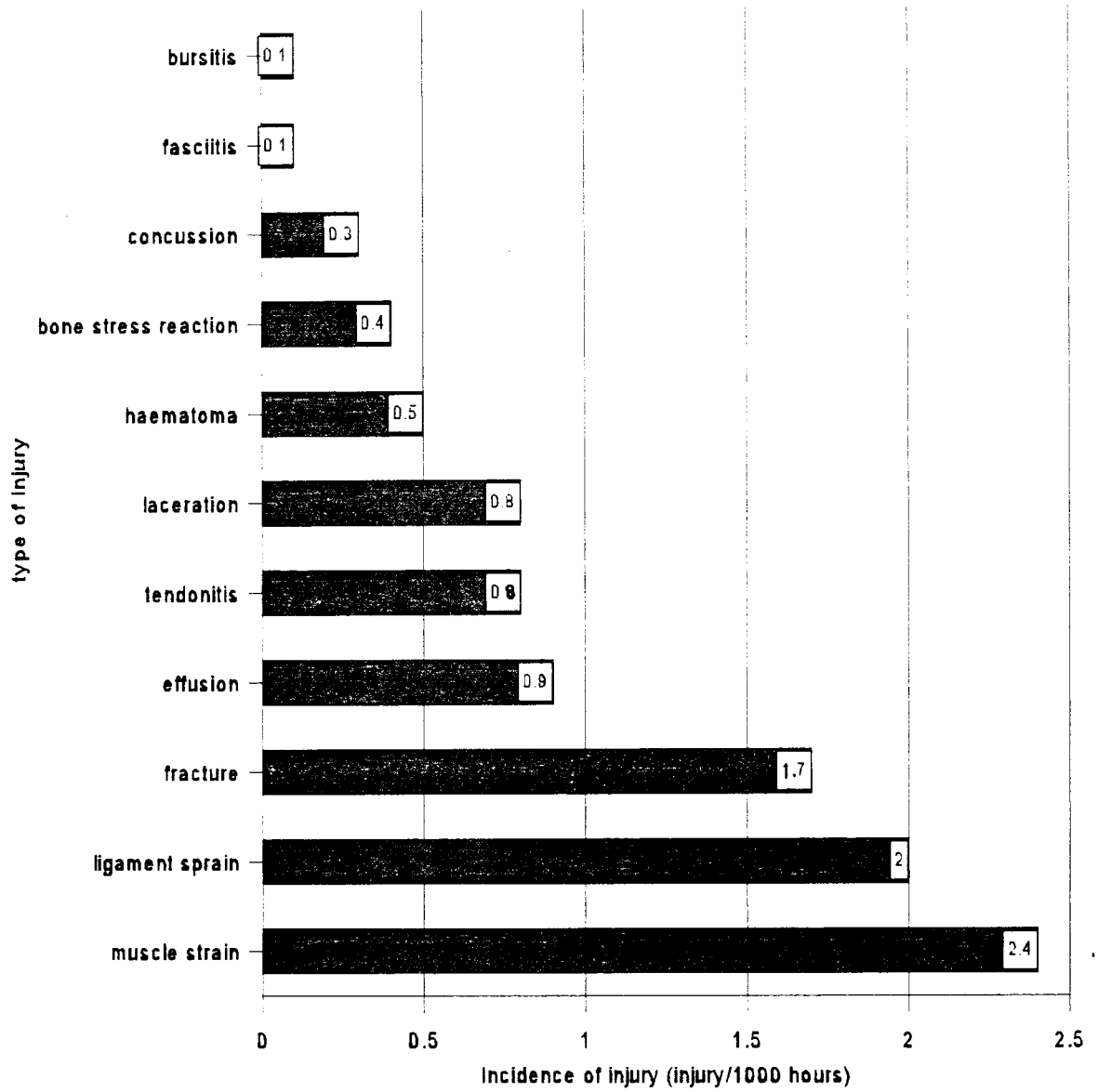



Figure 3.22 The incidence (injuries/1000 hours) of specific types of injury

Table 3.21 depicts the total incidence of each type of injury in male and female players. There was no significant difference in the type of injuries sustained by male and female hockey players.

Table 3.21 The incidence (injuries/1000 hours) of each specific injury type for the total population, and male and female players.

| Type | Male | Female |
|---|---|---|
| **strain** | 2.7 | 2.1 |
| **sprain** | 2.0 | 2.1 |
| **fracture** | 1.8 | 1.5 |
| **effusion** | 1.1 | 0.8 |
| **tendonitis** | 0.8 | 0.9 |
| **laceration** | 1.1 | 0.6 |
| **haematoma** | 0.5 | 0.5 |
| **bone stress injury** | 0.6 | 0.2 |
| **concussion** | 0.3 | 0.3 |
| **fascittus** | 0.2 | 0 |
| **bursitis** | 0 | 0.2 |

The incidence (injuries/1000 hours) of injury of each specific injury type for each age category and playing position is depicted in Table 3.22 and Table 3.23. There was no significant difference in the types of injuries sustained by the different age categories, nor was a significant difference evident between the four individual playing positions.

Table 3.22 The incidence (injuries/1000 hours) of each specific injury type for each age category

| Type | <20 years | 20-24 years | 25-29 years | >30 years |
|---|---|---|---|---|
| **strain** | 2.2 | 1.8 | 3.7 | 2.2 |
| **sprain** | 0.5 | 3.3 | 1.1 | 1.1 |
| **fracture** | 2.2 | 1.0 | 2.6 | 1.6 |
| **effusion** | 1.1 | 0.5 | 2.0 | 0 |
| **tendonitis** | 1.1 | 0.7 | 1.4 | 0 |
| **laceration** | 0.5 | 0.3 | 1.4 | 1.6 |
| **haematoma** | 0.5 | 0.7 | 0 | 0.5 |
| **bone stress reaction** | 0.5 | 0.5 | 0 | 0.5 |
| **concussion** | 0 | 0.3 | 0.6 | 0 |
| **fasciitis** | 0 | 0 | 0 | 0.5 |
| **bursitis** | 0 | 0 | 0 | 0.5 |

Table 3.23 The incidence (injuries/1000 hours) of each specific injury type for each player position

| Type | Striker | Midfielder | Defender | Goalkeeper |
|---|---|---|---|---|
| **strain** | 2.4 | 2.7 | 2.6 | 0.9 |
| **sprain** | 2.4 | 1.6 | 1.9 | 2.8 |
| **fracture** | 1.5 | 2.1 | 1.4 | 1.9 |
| **effusion** | 1.7 | 0.3 | 0.7 | 0.9 |
| **tendonitis** | 1.7 | 0.3 | 0.7 | 0.9 |
| **laceration** | 1.0 | 0.8 | 0.9 | 0 |
| **haematoma** | 0.7 | 0.5 | 0.2 | 0 |
| **bone stress reaction** | 0.2 | 0.5 | 0.5 | 0 |
| **concussion** | 0.2 | 0.3 | 0.2 | 0.9 |
| **fascittus** | 0 | 0 | 0.2 | 0 |
| **bursitis** | 0 | 0.3 | 0 | 0 |

The incidence of specific types of injury (injuries/1000 hrs) sustained to the anatomical regions (head, upper limb, pelvis/back and lower limb) are depicted in Table 3.24. The head region sustained the highest incidence (injuries/10000 hours) of lacerations (0.6/1000 hours), haematomas (0.2/1000 hours) and concussions (0.3/1000 hours). The upper limb had the greatest incidence of effusions (0.6/1000 hours) and the same incidence of haematomas as the head. The pelvis/back region sustained the highest incidence of bursitis (0.1/1000 hours). Together with the lower limb, it reported the highest incidence of muscle strains (1.1/1000 hours). The lower limb also had the highest incidence of ligament sprains (1.7/1000 hours), fractures (1.0/1000 hours), tendonitis (0.8/1000 hours), bone stress injuries (0.4/1000 hours) and fasciitis (0.1/1000 hours).

Table 3.24 The incidence of injury (injuries/1000 hrs) of each type of injury sustained at each anatomical region

| | **Head** | **Upper limb** | **Pelvis/back** | **Lower limb** |
|---|---|---|---|---|
| Strain (muscle) | 0.1 | 0.1 | 1.1 | 1.1 |
| Sprain (ligament) | 0 | 0.3 | 0.1 | 1.7 |
| Fracture | 0.4 | 0.3 | 0 | 1.0 |
| Effusion | 0 | 0.6 | 0 | 0.3 |
| Tendonitis | 0 | 0 | 0 | 0.8 |
| Laceration | 0.6 | 0.2 | 0 | 0 |
| Haematoma | 0.2 | 0.2 | 0 | 0.1 |
| Bone stress injury | 0 | 0 | 0 | 0.4 |
| Concussion | 0.3 | 0 | 0 | 0 |
| Fasciitis | 0 | 0 | 0 | 0.1 |
| Bursiitis | 0 | 0 | 0.1 | 0 |

## 3.9 Mechanism of injury

The mechanism of injury was defined as the phase of play during which the injury was sustained. The mechanisms of injury which resulted in the highest incidences of injury (injuries/1000 hrs) were tackling (2.3/1000 hrs), injuries of insidious onset (2/1000 hrs), and injuries due to the lifted ball (1.7/1000 hrs) (Figure 3.23)

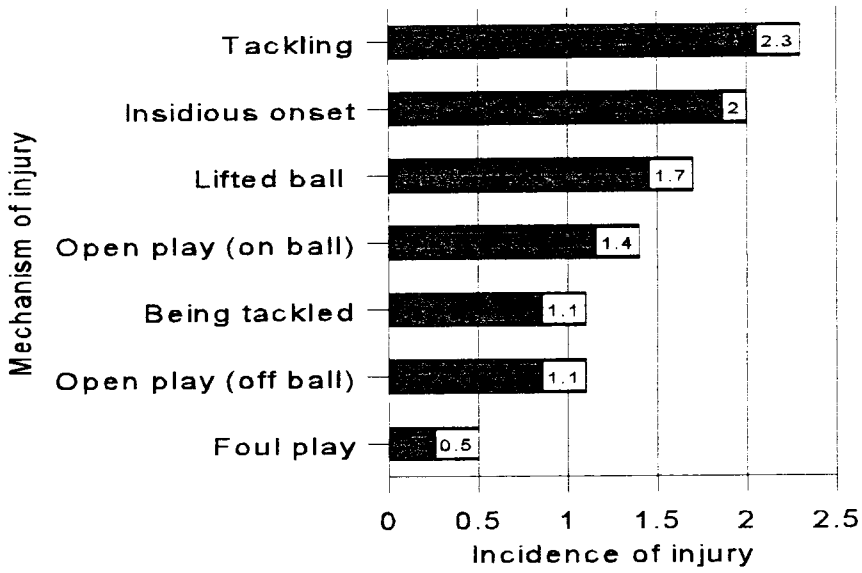



Figure 3.23 The incidence of injury (injuries/1000 hrs) resulting from each specific mechanism of injury

The incidence of injury (injuries/1000 hrs) of different mechanisms of injury in male and female players are depicted in Table 3.25. There were no significant differences in incidence of injury due to the various mechanisms of injury between male and female hockey players.

Table 3.25 The incidence (injuries/1000 hours) of each specific mechanism of injury for male and female players

| | **Male** | **Female** |
|---|---|---|
| Tackling | 2.3 | 2.3 |
| Insidious onset | 2.1 | 1.8 |
| Lifted ball | 1.8 | 1.5 |
| Open play (on ball) | 1.8 | 1.1 |
| Being tackled | 1.1 | 1.1 |
| Open play (off ball) | 1.1 | 1.1 |
| Foul play | 0.6 | 0.5 |

The incidence of different mechanisms of injuries (injuries/1000 hrs) in the four different age categories is depicted in Table 3.26. The highest incidence of all the mechanisms of injury was recorded in the 20-24 and 24-29 year old categories. The 25-29 year old players had a significantly higher incidence of injury during tackling than the other age categories ($p=0.0024$).

Table 3.26 The incidence (injuries/1000 hours) of each specific mechanism of injury for each age category (yrs)

| | <20 yrs | 20-24 yrs | 25-29 yrs | >30 yrs |
|---|---|---|---|---|
| Tackling | 2.7 | 1.0 | 4.3* | 2.1 |
| Insidious onset | 2.2 | 1.7 | 2.3 | 2.1 |
| Lifted ball | 0.5 | 1.7 | 2.3 | 1.6 |
| Open play (on ball) | 0.5 | 1.8 | 1.7 | 0.5 |
| Being tackled | 2.2 | 1.3 | 0.3 | 0.5 |
| Open play (off ball) | 0 | 1.5 | 0.6 | 1.6 |
| Foul play | 0.5 | 0.3 | 0.9 | 0.5 |

*: $p<0.05$ (25-29 year old players versus the other 3 age categories)

The incidence of different mechanisms of injury (injuries/1000 hrs) in different player positions is depicted in Table 3.27. Goalkeepers sustained significantly more injuries due to tackling than outfield players (p=0.0473).

Table 3.27 The incidence (injuries/1000 hours) of each specific mechanism of injury for each playing position

| | Striker | Midfielder | Defender | Goalkeeper |
|---|---|---|---|---|
| Tackling | 2.9 | 1.6 | 1.6 | 4.7* |
| Insidious onset | 1.7 | 2.1 | 2.6 | 0 |
| Lifted ball | 1.5 | 1.5 | 1.9 | 1.9 |
| Open play (on ball) | 1.7 | 1.9 | 0.9 | 0.9 |
| Being tackled | 1.5 | 1.1 | 0.9 | 0 |
| Open play (off ball) | 1.0 | 0.8 | 1.6 | 0 |
| Foul play | 0.5 | 1.1 | 0.2 | 0 |

*p<0.05 (goalkeeper versus outfield players)

The incidence of specific mechanisms of injury in each anatomical region are depicted in Table 3.28. A significant number of injuries to the head region resulted from tackling (p=0.00002) and the lifted ball (p=0.000005), compared to the other mechanisms of injury. Similarly, upper limb injuries were significantly more common due to tackling (p=0.075), being tackled (p=0.00303) and the lifted ball (p=0.0000006). A significant number of pelvis/back injuries developed insidiously (p=0.00008), while a significant number of lower limb injuries were due to being tackled (p=0.0009), open play, both on (p=0.000375) and off (p=0.000159) the ball, and injuries of insidious onset (p=0.00000345).

Table 3.28 The incidence (injuries/1000 hours) of the specific mechanisms of injury at each anatomical region

| | **Head** | **Upper limb** | **Pelvis/back** | **Lower limb** |
|---|---|---|---|---|
| Tackling | 0.6* | 0.6* | 0.3 | 0.7 |
| Insidious onset | 0 | 0.1 | 0.7* | 1.1* |
| Lifted ball | 0.7* | 0.8* | 0 | 0. |
| Open play (on ball) | 0 | 0.2 | 0.2 | 1.1* |
| Being tackled | 0.1 | 0.4* | 0 | 0.6* |
| Open play (off ball) | 0 | 0.2 | 0.1 | 0.8* |
| Foul play | 0.2 | 0.2 | 0 | 0.2 |

*: $p<0.05$ (mechanism of injury versus injury region)

The incidence of specific mechanisms of injury resulting in specific types of injury is depicted in Table 3.29. No specific mechanism of injury resulted in significantly more of a particular type of injury.

Table 3.29 The incidence (injuries/1000 hours) of the specific mechanisms of injury resulting in the specific types of injury

| | Tackling | Insidious onset | Lifted ball | Open play on ball | Being tackled | Open play off ball | Foul play |
|---|---|---|---|---|---|---|---|
| Strain | 0.5 | 0.8 | | 0.5 | 0.2 | 0.5 | |
| Sprain | 0.4 | 0.1 | | 0.7 | 0.2 | 0.5 | 0.1 |
| Fracture | 0.3 | 0.1 | 0.6 | 0.2 | 0.3 | 0.2 | 0.1 |
| Effusion | 0.2 | | 0.5 | | 0.1 | | 0.2 |
| Tendonitis | 0.2 | 0.5 | | 0.1 | 0.2 | | 0.1 |
| Laceration | 0.3 | | 0.5 | | | | 0.1 |
| Heamatoma | 0.2 | | 0.2 | | 0.1 | | 0.1 |
| Bone sr* | 0 | 0.4 | | | | | |
| Concussion | 0.2 | | | | 0.1 | | |
| Fasciitis | | 0.1 | | | | | |
| Bursitis | | 0.1 | | | | | |

*: bone sr = bone stress injury

### 3.3.10 Severity of injury

#### 3.3.10.1 The influence of the injury on the injured players ability to complete the match/practice

Of the injured players, 92 (70%) could not complete the hockey activity that they were involved in at the time of injury. Male players just as likely to discontinue a match/practice (n=50; 69%) as their female counterparts (n=42; 70%).

Players older than 30 years were more likely to stop playing at the time of injury (n=12; 75%), than any of the other age categories, which saw 69% of the injured players younger than 20, 68% of 20-24 year olds and 70% of 25-29 year old players not completing the match or practice because of the injury. However, these findings were not significant.

There was no significant differences in the ability of the various player positions to complete a match or practice. Strikers (n=32; 76%) and goalkeepers (n=6; 75%) were the two positions that were most affected at the time of injury in terms of having to cease play, compared to midfielders (n=26; 68%) and defenders (n=28; 67%).

#### 3.3.10.2 Injuries that required medical attention

Ninety (68%) of the 132 injuries sustained by hockey players during the 1995 season required medical attention. Similar percentages of male (67%) and female (70%) players sought medical attention for their injuries.

The youngest players in the population, those less than 20 years, consulted medical personnel most frequently (88%) for their injuries. The oldest players, those 30 years and older, also required frequent medical attention (81%). The 20-24 (65%) and 25-29 (60%) year old players sought medical attention less often. Midfielders (82%) required more medical attention compared to defenders (71%), goalkeepers (63%) and strikers (55%).The differences between both the age categories and player positions were not significant.

### 3.3.10.3 Matches/practices missed due to injury

The 132 injuries reported in the 1995 season resulted in a total of 491 matches or practices being missed, although not every injury resulted in time off hockey. Eighty-three (63%) of the injuries caused the injured player to miss a subsequent match/s or practice/s, with a mean of four matches or practices per injury. Injuries to the lower limb resulted in the greatest number of missed matches or practices (n=213; 43%) of the total number of matches or practices missed, compared to the upper limb (n=165; 34%), head (n=86; 18%) and the pelvis/back (n=27; 5%), as depicted in Table 3.30. This table also depicts the number of injuries at each site that resulted in matches or practices being missed, as well as the mean number of matches or practices missed at each anatomical site (total number of matches or practices missed divided by the total number of injuries at that site). The injury sites with the highest mean number of matches or practices missed per injury were the jaw (20), neck (12) and elbow (10).

Table 3.30 The total number and percentage (in brackets) of injuries at specific anatomical sites that resulted in the injured player missing subsequent matches/practises

| Site of injury | Total Injuries at that site | Injuries resulting in missed matches/ practices | Total number of missed matches/ practices | Mean number of matches/practices missed per injury |
|---|---|---|---|---|
| 1. Head | 21 (16%) | 13 (62%) | 86 (18%) | 4 |
| head | 7 | 4 | 9 | 1 |
| eye | 7 | 4 | 4 | 1 |
| nose | 1 | 1 | 2 | 2 |
| mouth | 2 | 0 | 0 | 0 |
| jaw | 3 | 3 | 59 | 20 |
| neck | 1 | 1 | 12 | 12 |
| 2. Upper Limb | 32 (24%) | 20 (63%) | 165 (34%) | 5 |
| shoulder | 1 | 1 | 1 | 1 |
| elbow | 2 | 2 | 20 | 10 |
| wrist | 8 | 7 | 59 | 7 |
| fingers | 21 | 10 | 85 | 4 |
| 3. Pelvis/back | 17 (13%) | 8 (47%) | 27 (5%) | 2 |
| back | 9 | 5 | 19 | 2 |
| hip | 2 | 0 | 0 | 0 |
| groin | 6 | 3 | 8 | 1 |
| 4. Lower Limb | 62 (47%) | 42 (68%) | 213 (43%) | 3 |
| hamstrings | 11 | 8 | 24 | 2 |
| knee | 18 | 11 | 27 | 2 |
| Anterior lower leg | 6 | 2 | 24 | 4 |
| calf | 4 | 2 | 4 | 1 |
| ankle | 18 | 16 | 120 | 7 |
| achilles | 1 | 0 | 0 | 0 |
| foot | 4 | 3 | 14 | 4 |
| TOTAL | 132 | 83 | 491 | 4 |

Similar numbers of matches or practices were missed due to injury by male (n=247) and female (n=244) players (p=0.7191). The average number of matches or practices missed due to injury was the greatest for the injured players younger than 20, and the 20-24 year old players (n=4), followed by the injured 25-29 year old players and those injured players older than 30 (n=3) (Table 3.31). The injured strikers (n=4), midfielders (n=4) and goalkeepers (n=4) were the positions that missed the most matches or practices on average, compared to the injured defenders (n=3), as depicted in Table 3.32.

Table 3.31 The total number of injuries sustained by each age category and total number of matches/practices missed due to injury in each category

| | Total injuries | Total matches/practices missed |
|---|---|---|
| <20 yrs | 16 | 60 |
| 20-24 yrs | 57 | 266 |
| 25-29 yrs | 43 | 113 |
| >30 yrs | 16 | 52 |

Table 3.32 The total number of injuries sustained by each player position and total number of matches/practices missed due to injury in each position

| | Total injuries | Total matches/practices missed |
|---|---|---|
| Striker | 44 | 181 |
| Midfielder | 38 | 158 |
| Defender | 42 | 121 |
| Goalkeeper | 8 | 31 |

### 3.3.10.4 Medical personnel consulted by the injured players

Ninety (68%) of the injuries resulted in the player seeking medical attention. The medical professionals consulted included doctors (n=45; 50%), physiotherapists (n=39, 43%), chiropractors (n=4; 5%), and an orthotist (n=1; 1%) and dentist (n=1; 1%).

As depicted in Table 3.33, the doctors saw the majority of head (n=12; 86%) and upper limb (n=21; 88%) injuries, whereas the physiotherapists dealt with the majority of pelvis/back (n=9; 69%) and lower limb (n=27; 69%) injuries.

Table 3.33 The number and percentage (in brackets) of injuries in specific anatomical sites that required the attention of a medical professional

| Site | Doctor | Physio* | Chiropractor | Orthotist | Dentist | Total |
|---|---|---|---|---|---|---|
| 1.Head | 12 (86%) | 0 | 1 (2%) | 0 | 1 (2%) | 14 |
| Head | 4 | | | | | |
| Eye | 4 | | | | | |
| Nose | 1 | | | | | |
| Jaw | 3 | | | | | |
| Mouth | | | | | 1 | |
| Neck | | | 1 | | | |
| 2.Upper limb | 21(88%) | 3 (2%) | 0 | 0 | 0 | 24 |
| Shoulder | | | | | | |
| Elbow | 2 | | | | | |
| Wrist | 4 | 1 | | | | |
| Fingers | 15 | 2 | | | | |
| 3.Pelvis/back | 1 (8%) | 9 (69%) | 3 (23%) | 0 | 0 | 13 |
| Back | 1 | 4 | 2 | | | |
| Hip | | 1 | 1 | | | |
| Groin | | 4 | | | | |
| 4.Lower limb | 11(28%) | 27 (69%) | 0 | 1 (3%) | 0 | 39 |
| Hamstrings | | 4 | | | | |
| Knee | 3 | 8 | | 1 | | |
| Anterior lower leg | 2 | 4 | | | | |
| Calf | | 2 | | | | |
| Ankle | 3 | 8 | | | | |
| Achilles tendon | 1 | | | | | |
| Foot | 2 | 1 | | | | |
| **Total** | 45 | 39 | 4 | 1 | 1 | |

*: Physiotherapist

3.3.10.5 The procedure or investigation by a medical professional that was necessitated due to injury

Investigations or procedures were required in 55 (42%) of the injuries. Of these, x-rays (n=22; 40%) and stitches (n=10; 18%) were most frequently required (Figure 3.24).

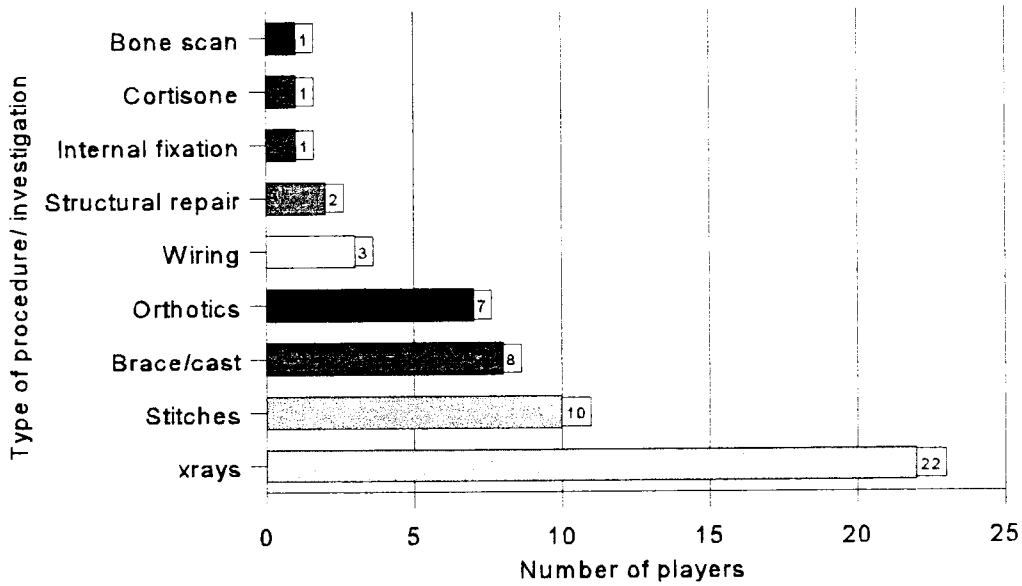



Figure 3.24 Type of investigation/procedure received by injured players

X-rays were requested most frequently for finger injuries (n=8), followed by injuries to the wrist (n=3), jaw, anterior lower leg and ankle (n=2) and head, neck, hip and knee (n=1). Stitches were required exclusively to the head and upper limb regions. A significant number of the injuries to the head region required stitches (p=0.000002). Bracing was most frequently required for the ankle (n=5; 63%). Fifty-seven percent of the orthotics prescribed were for injuries to the anterior or medial lower leg (n=4).

### 3.3.11 Playing surface

The two surfaces utilized by the sample population were grass, on which they practised once a week, and artificial turf, on which all matches were played, as well as one weekly practise. The total number of hours played on grass was 4622, and on artificial turf, 8561.The number, incidence, site, type, mechanism and severity of injury on both surfaces was recorded.

#### 3.3.11.1 The number and incidence of injury on each specific surface

There was a significant difference in the incidence of injury sustained on the two different surfaces. On artificial turf the incidence of injury (injuries/1000 hours) was 13.2/1000 hours (n=113), compared with 4/1000 hours on grass (n=19) (p=0.015). Male and female players reported similar incidences of injury on either surface (Figure 3.25).

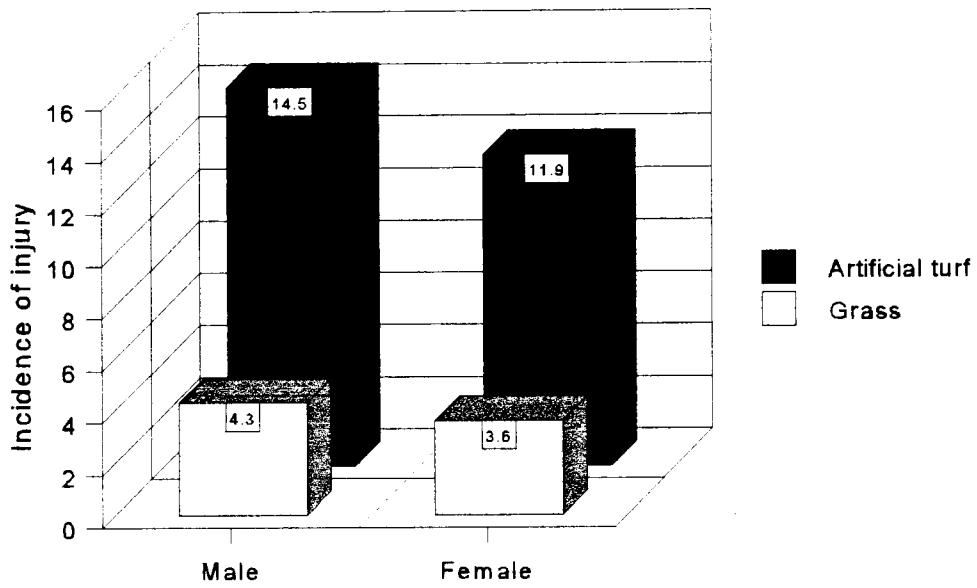



Figure 3.25 The incidence of injury for male and female players that were injured on grass and artificial turf

A similar trend as for the total population was evident in all the age categories and playing positions, in that a significant number of all injuries were sustained on artificial turf. These data are depicted in Table 3.34 and Table 3.35.

Table 3.34 The number (N) and incidence (injuries/1000 hours) of injury sustained on artificial turf and grass by each age category

| | **Artificial turf** | | **Grass** | |
|---|---|---|---|---|
| | N | Incidence | N | Incidence |
| <20 yrs | 14 | 12.0* | 2 | 2.9 |
| 20-24 yrs | 48 | 12.2* | 9 | 4.4 |
| 25-29 yrs | 38 | 16.7* | 5 | 4.1 |
| >30 yrs | 13 | 11.1* | 3 | 4.5 |

*$p<0.05$ (artificial turf versus grass)

Table 3.35 The number (N) and incidence (injuries/1000 hours) of injury sustained on artificial turf and grass by each playing position

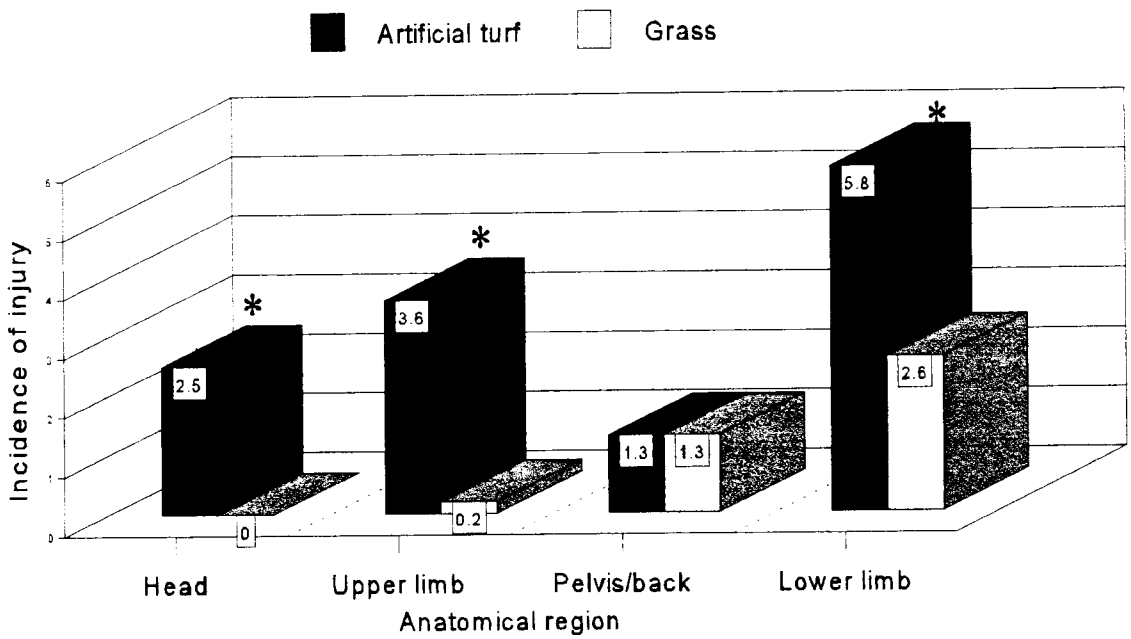
| | **Artificial turf** | | **Grass** | |
|---|---|---|---|---|
| | N | Incidence | N | Incidence |
| Striker | 39 | 14.3* | 5 | 3.7 |
| Midfielder | 33 | 13.2* | 5 | 4.0 |
| Defender | 33 | 11.6* | 9 | 6.3 |
| Goalkeeper | 8 | 11.2* | 0 | 0 |

*$p<0.05$ (artificial turf versus grass)

### 3.3.11.2 Site of injury specific to surface

Certain anatomical sites were injured exclusively on a particular surface. All head injuries occurred whilst playing on artificial turf (n=21), as did all elbow, wrist, groin and calf injuries. Those injuries sustained exclusively on grass included the hip (n=2) and achilles tendon (n=1).

Significantly more head, upper and lower limb injuries were sustained on artificial turf compared to grass ($p<0.05$), as depicted in Figure 3.26. The incidence of injury to the pelvis/back was the same for both surfaces (1.3/1000 hours).




*$p<0.05$ (grass versus artificial turf)

Figure 3.26 The incidence (injuries/1000 hours) of injury at each anatomical region on artificial turf and grass

### 3.3.11.3 Type of injury specific to surface

There was no significant difference between the types of injury sustained on artificial turf compared to grass, with the exception of fractures, which were sustained significantly more on artificial turf ($p=0.001$) (Table 3.36).

Table 3.36 The number of specific types of injury sustained on artificial turf and grass

| **Type** | **Artificial turf** | **Grass** |
|---|---|---|
| Strain | 26 | 6 |
| Sprain | 21 | 6 |
| Fracture | 22* | 0 |
| Effusion | 11 | 1 |
| Tendonitis | 9 | 2 |
| Laceration | 11 | 0 |
| Haematoma | 6 | 0 |
| Stress syndrome | 3 | 2 |
| Concussion | 4 | 0 |
| Fasciitis | 0 | 1 |
| Bursitis | 0 | 1 |

*:$p<0.05$ (grass versus artificial turf)

### 3.3.11.4 Mechanism of injury specific to surface

The incidence of a specific mechanism of injury was higher on artificial turf for all mechanisms, with the exception of injuries of insidious onset, which had a higher incidence on grass, as depicted in Table 3.35. Significantly more injuries sustained whilst tackling, being tackled, lifted ball and open play (on the ball) occurred on artificial turf compared to grass (Table 3.37).

Table 3.37 The incidence (injuries/1000 hours) of each mechanism of injury specific to surface

| **Mechanism** | **Artificial turf** | **Grass** |
|---|---|---|
| Tackling | 3.3 | 0.4* |
| Insidious onset | 1.5 | 2.4 |
| Lifted ball | 2.7 | 0* |
| Open play (on ball) | 2.1 | 0.4* |
| Being tackled | 1.6 | 0* |
| Open play(off ball) | 1.2 | 0.9 |
| Foul play | 0.8 | 0 |

*$p<0.05$ (grass versus artificial turf)

3.3.11.5 Injuries sustained during a match or practice on a particular surface

All the injuries that were sustained on grass (n=19) occurred during practice, whereas 98% of injuries on artificial turf were sustained whilst playing matches (n=111), with the remaining two occurring during practise.

3.3.11.6 Severity of injury specific to surface

Players injured on artificial turf were more likely not to complete the match/practice (73%) compared with those players injured on grass (53%). A similar number of injuries sustained on both surfaces required medical attention (artificial turf=66%, grass=68%). The consequences of injury in terms of matches/practices missed due to injury was more pronounced on artificial turf. On artificial turf, 92 of the 113 injuries (81%) sustained on this surface resulted in the injured player missing subsequent matches/practices. An average of 5 matches/practices were

missed by the injured player due to the injury. Forty-one (41) of the 95 injuries sustained on grass (43%) resulted in the injured player missing subsequent matches/practices. This was significantly less compared with artificial turf ($p=0.014$). The average number of matches/practices missed due to injury was the same as for artificial turf ($n=5$).

### 3.3.12 The relationship of risk factors to injury in field hockey players

The following section presents the results of the various risk factors detailed in the player profile questionnaire and pre-season fitness assessment (Part I) to the epidemiology of injury (Part II), with particular reference to pre-season training, training methods, equipment and pre-season fitness assessments.

#### 3.3.12.1 Pre-season Training

The effect of pre-season training on the pre-season fitness test results was varied. No significant difference between sit and reach ($p=0.780$) or 40 m sprint ($p=0.4207$) results were reported between players who participated in pre-season training and those who did not. However, a significant difference was noted in the standing broad jump ($p=0.015$) and winder 1 of the double winder ($p=0.0585$) for players participating in pre-season training. No such difference was evident for winder 2 ($p=0.2106$).

There was no significant relationship between participation in pre-season training and predisposition to injury, either in general or specific to the various anatomical regions, namely the head ($p=0.625$), upper limb ($p=0.855$), pelvis and lower back ($p=0.768$) and lower limb ($p=0.679$), as depicted in Table 3.38.

Table 3.38 The incidence (injuries/1000 hours) of injury sustained by players who did and did not participate in pre-season fitness at each specific anatomical region

| | Incidence of injury of players who partook in pre-season fitness | Incidence of injury of players who did not partake in pre-season fitness |
|---|---|---|
| Head | 1.6 | 1.6 |
| Upper limb | 2.2 | 3.2 |
| Pelvis/back | 1.0 | 2.5 |
| Lower limb | 4.0 | 7.8 |

3.3.12.2 Stretching regime

The relationship between stretching and injury could be assessed by comparison of the sit and reach scores of those players that sustained hamstring injuries and those who did not. The mean score of the players reporting a hamstring injury (n=16) was 88±16 mm, compared with the 98± 17 mm of the players that did not sustain a hamstring injury (n=206). This was not a significant difference (p=0.9682).

3.3.12.3 Equipment used by field hockey players

3.3.12.3.1 Footwear

There was no significant differences between incidence of injury to the ankle (p=1.000), Achilles tendon (p=1.000) or foot (p=0.169) by players wearing hockey boots or running shoes (Table 3.39). There was also no significant difference in the incidence of ankle injury amongst players wearing the various types of hockey boots.

Table 3.39 The incidence (injuries/1000 hours) of injury to the ankle, Achilles tendon and foot in players wearing hockey boots and running shoes

| Injury site | Hockey boot (n=126) | Running shoe (n=6) |
|---|---|---|
| Ankle | 1.4 /1000 hours | 0 /1000 hours |
| Achilles tendon | 0.1 /1000 hours | 0 /1000 hours |
| Foot | 0.2 /1000 hours | 2.8 /1000 hours |

3.3.12.3.2 Mouth protectors

The 99 players who wore mouth protectors sustained no mouth injuries in the 1995 season, whilst the two players who did suffer a mouth injury (0.3 injuries/1000 hours) were not wearing mouth protectors. There was no significant difference in the number of mouth injuries sustained by players with mouth protectors and those without (p=0.504).

3.3.12.3.3 External support/protection devices

There were no significant differences between those players who used any of the supportive/ protective devices and those players who did not, and decreased risk of injury at the particular sites at which the supportive/protective devices were worn (Table 3.40 toTable 3.42).

Table 3.40 The relationship between wearing a finger guard and finger injury

| | Players with finger injury | Players with no finger injury |
|---|---|---|
| Wearing finger guards | 2 | 34 |
| Not wearing finger guards | 19 | 167 |

p=0.540

Table 3.41 The relationship between wearing a knee guard and knee injury

| | Players with knee injury | Players with no knee injury |
|---|---|---|
| Wearing a knee guard | 2 | 7 |
| Not wearing a knee guard | 14 | 199 |

p=0.13

Table 3.42 The relationship between wearing an ankle brace and ankle injury

| | Players with ankle injury | Players with no ankle injury |
|---|---|---|
| Wearing an ankle guard | 2 | 23 |
| Not wearing an ankle guard | 14 | 183 |

p=0.698

3.3.12.4 The association of pre-season fitness assessment results and injury

3.3.12.4.1 **Sit and reach test**

See section 3.3.12.2

3.3.12.4.2 **Standing broad jump**

There were no quadriceps injuries reported by players in the 1995 prospective study, thus the results of the standing broad jump of players who sustained calf injuries were compared with those players who did not sustain such an injury. There was no significant difference between the mean (cm) standing broad jump of players who sustained a calf injury during the prospective study, and those that did not (p=0.3165).

#### 3.3.12.4.3 **40 m Sprint**

There was no significant difference in the 40 m sprint times of those players that sustained injury and those who didn't ($p=0.4207$).

#### 3.3.12.4.4 **Double winder**

The association between double winder times and injuries of insidious onset was investigated. The average double winder times of players who sustained injuries of insidious onset and those that didn't, were compared. There was no significant difference between the double winder times of the two groups ($p=0.3454$).

# Chapter Five

# DISCUSSION

**Contents**

## 5.1 Introduction

The results of this study will now be discussed in two sections, Part I and II. The findings of the player profile questionnaire, with specific reference to seasonal incidence of injury, training methods and stretching protocol, will be discussed in Part I, followed by a discussion of the pre-season fitness test results, with reference to the influence of age, gender and playing position on each specific test, as well as injury risk associated with less than average scores. The epidemiology of injuries in field hockey will be discussed in Part II, particularly the relationship of injury to variables such as age, gender, time of season, match play, player position, site of injury, mechanism, type of injury, severity and surface.

**Part I: Player profile questionnaire and pre-season fitness assessment**

## 5.2 Player profile questionnaire

The player profile questionnaire established a data base of information on the population of players with respect to previous seasons injury history, pre-season training methods, stretching protocols and equipment usage. The relationship between the afore-mentioned variables and injury risk was investigated, as was the relationship between these variables and the results of the pre-season fitness tests. Each of the variables (previous seasons injury history, pre-season training methods, stretching protocols, equipment usage) will now be discussed in further detail, with reference to injury and pre-season fitness test results where applicable.

5.2.1 Seasonal incidence of injury (retrospective analysis of 1994 season)

The seasonal incidence (%) during the 1994 retrospective study was 52% compared with the 59% reported in the 1995 prospective study. No previous epidemiological studies of field hockey injuries have documented the seasonal incidence of injury. However, as the seasonal incidence in both the 1994 and 1995 study are relatively similar, it can be hypothesised that the findings of our study may indeed be representative of the general hockey playing population.

Furthermore, the most frequent sites of injury recorded in the retrospective (1994) study were the same as those documented in the 1995 prospective study. The most common sites of injury were the fingers, ankle, knee and hamstrings.

The only significant difference between the incidence of injuries sustained at the various anatomical regions in the retro- and prospective studies, was that significantly more injuries to the upper limb were recorded in the 1995 season. Significantly more finger injuries were recorded in the 1995 season.

It can be hypothesised that previous injury at a particular anatomical site may predispose a player to an injury at that same site in the future. However, there was no evidence that associated an injury sustained by a player at a specific anatomical site in the retrospective study (1994) as recurring during the prospective study (1995). As injuries prior to 1994 were not recorded, it is possible that a player could have sustained an injury prior to 1994.

In summary, both the retro- and prospective studies documented a similar seasonal incidence of injury, as well as reporting the same anatomical sites as being the most frequently injured.

These particular anatomical sites of injury (ankle, knee, hamstring muscle) were also reported in other epidemiological studies of field hockey injuries (Rose 1981, Jamieson and Lee 1989), which leads to the assumption that injuries to the ankle, knee and hamstrings are indeed representative of the injuries most frequently sustained by field hockey players. No relationship was established between previous (1994) and current (1995) injury.

### 5.2.2 Training methods

#### 5.2.2.1 Pre-season training

There was no significant difference between male and female participation in pre-season training, with the exception that significantly more female players participated in weight training compared with male players. There were no significant differences between the types of pre-season training performed by the four different age groups or player positions.

The lack of relationship between participation in pre-season training and improved pre-season fitness was an unexpected finding. It was hypothesised that players who participated in pre-season training would achieve better results in the four fitness tests than those players who did not train. However, the only significant relationship between participation in pre-season training and pre-season fitness test results was in the standing broad jump. Players who participated in pre-season training jumped significantly further than players who did not perform pre-season training. A marginally significant difference was documented for Winder 1 times, with players who did not train in the pre-season recording slower times than those who did. However, no such difference was evident between the Winder 2 times. This was an unexpected finding as it was assumed that those players who performed pre-season training

would record faster times than players who did not train pre-season. A reason for the lack of relationship between participation in pre-season training and improved pre-season fitness test results may be due to the nature of the training. It was possible that the pre-season training performed was not the correct type of training, or was not of sufficient duration. A more detailed study of the nature and specificity of pre-season training needs to be undertaken.

The possible relationship between non-participation in pre-season training and the predisposition to injury through lack of adequate preparation was also investigated. However, no significant relationship between players who did not participate in pre-season training and increased injury risk was identified. Thus, although it is generally accepted that one of the benefits of pre-season training is to protect against injury (Peterson and Renstrom 1986), such a finding was not apparent in our study population. However, stating that such a relationship does not exist is based on the assumption that the pre-season training of the study population was both adequate and appropriate. Such an assumption cannot be made on the basis of data reported in this study, as only the type of pre-season activity was recorded, with no specific reference to the duration, frequency, nature and specificity of the activity. It is thus possible that the finding that pre-season training does not protect against injury may be related to the lack of specificity or duration of pre-season training of the injured players. Further investigation is required.

In summary, although the majority of the sample population (82%) participated in pre-season training, there appears to be no apparent benefit derived from such training in terms of injury prevention, and only a limited benefit to pre-season fitness. However, this finding is not conclusive, as the nature and duration of the pre-season training needs to be taken into account. It is possible that the pre-season training undertaken by the study population was not adequate.

5.2.2.2 Participation in other sports during the hockey season

A comparison of the injury risk and incidence of injury in players involved in other sports compared with those who only played hockey during the winter, revealed that no significant difference in the injury rates existed between the two groups. Furthermore, those involved in other sports were not prone to any particular site or type of injury that could be related to their participation in another sport.

These results therefore do not support a hypothesis that the participation in other sports by a player during the hockey season may predispose that player to injury.

5.2.2.3 Stretching protocol

The hockey players in this study did not follow a stretching protocol that is currently recommended in the literature (Wilkinson 1992, Smith 1994).

A recent well-conducted scientific study has shown that a stretch duration of at least 30 seconds was ideal (Hughes 1996). The longest duration of a stretch amongst the players was 16-20 seconds (8% of the population).

It has been shown that the amount of stress relaxation occurring in a muscle that is stretched is less during the first ten seconds than that occurring in the subsequent ten seconds (Taylor et al 1990, Wilkinson 1992, Smith 1994). The implication is that those players stretching for less that ten seconds are probably not gaining the same benefit from the stretch than had they held the stretched position for a period longer than 10 seconds. Such a hypothesis is substantiated

by the findings of Hughes (1996). In fact, half of the sample population (50%) only held their stretch for between six and ten seconds. There is thus the possibility that a large part of the population is gaining little or no benefit from there stretching routine.

Recent studies have also shown that a stretch should be repeated three to five times (Wilkinson 1992, Smith 1994, Hughes 1996). In this study, less than half the players (42%) repeated a stretch three times or more. The remaining players stretched twice or less (58%). Again, it can be postulated that over half of the sample population were not gaining the optimum benefit from their stretching routine, and were also probably unaware of this fact.

It is thus clear that most of the players in this study did not stretch effectively. These poor stretching habits may increase the injury risk of players, as well as affecting the results obtained in the pre-season fitness assessments, particularly the sit and reach test.

The entire cohort of players did stretch, with the exception of one individual, and it was therefore not possible to determine whether no stretching had any effect on the susceptibility of a player to injury.

The relationship between flexibility and injury risk was examined by analysing the sit and reach test results and injury risk. The relationship between hamstring muscle injury and sit and reach scores showed no significant difference in flexibility between the injured (88$\pm$16 mm) and non-injured (98$\pm$17 mm) groups, and only a trend was evident in that players who sustained hamstring muscle injuries had lower sit and reach scores.

Reasons for the lack of relationship between poor hamstring flexibility and increased risk of hamstring injury may be due to the small number of subjects that sustained a hamstring injury (n=11). Also, as injuries are multifactorial, it is possible that factors other than flexibility contributed to injury. These factors could include muscle weakness, muscle imbalance, poor proprioception and previous injury (Bruckner and Khan 1993).

### 5.2.3 Equipment used by hockey players

#### .5.2.3.1 Mouth protectors

Previous research documents that dental injuries are common in hockey players. Retrospective studies of two different hockey playing populations showed that the lifetime prevalence of dental injury in players was 32-66% (Bolhuis 1986, Bolhuis 1987). In our study only two dental injuries were reported in 1995 (prospective study), and three injuries were documented in 1994 (retrospective study). This number is small and cannot be compared to the lifetime prevalence data of Bolhuis (1986, 1987).

It is believed that the majority of dental trauma can be prevented by wearing a mouth protector (Bolhuis 1987). This notwithstanding, many of the hockey players in this study (55.4%), as in other studies (Bolhuis 1986, Bolhuis 1987), did not use this protective device. This finding was similar to the results of a retrospective study of international players, which documented that 57% of the studied population didn't wear mouth protectors (Bolhuis 1987).

Of the 99 players (44.6%) in this study who used mouth protectors, only 39.4% (n=39) wore one at both matches and practices, with the remainder (60.6%) only wearing them during

matches. This again was similar to what was documented in a retrospective study of international hockey players, which reported that only 20% of the players researched wore a mouth protector all the time (Bolhuis 1987).

The reason why players use the mouth protector more in matches, compared to practices, may be that match play is viewed as the more dangerous situation. This belief is substantiated by the findings of numerous epidemiological studies, which cite the majority of injuries as occurring in a match as opposed to a practice (Ekstrand and Gilquist 1983, Clark et al 1990, Stretch 1993).

In summary, although dental injuries do not have a high seasonal incidence (2%), studies have shown a lifetime prevalence of 32-66% (Bolhuis 1987). This evidence is sufficient to recommend that mouth protectors be worn regularly, as it is believed that injury can be prevented or minimized through the use of this device (Bolhuis 1987). Unfortunately, few players use a mouth protector, and those that do are selective in its' use, choosing to wear it predominantly in matches. Reasons for the poor usage of this device may be the expense involved or that it is uncomfortable to wear.

#### 5.2.3.2 Footwear

The relationship between footwear, playing surface and injury risk has been investigated in numerous studies (Torg 1973, Torg 1974, Andreasson 1986, Torg 1996). The shoe-playing surface interface has been implicated in the aetiology of ankle injury. In particular, the fixation of the foot to the surface, known as "foot-fix", has been cited as a possible aetiological factor of injury (Torg 1996).

In our study all 18 ankle injuries were sustained by players wearing hockey boots. Evidence from other studies suggested that boots with cleats potentially increase the interface friction between the shoe and playing surface, causing a greater "foot-fix", than un-cleated boots, and thereby increasing the risk of injury (Torg 1974, Andreasson 1986, Torg 1996). In our study, all the players wore cleated boots and it was not possible to investigate the relationship between boots, cleats and injury risk. There was no significant difference in ankle injury rates between the different models of cleated boots worn by the sample population in our study.

A significant number of ankle injuries were sustained during open play, either on or off the ball. The mechanism of injury in all the ankle injuries could be attributed to a sudden directional change. The influence of shoe surface interface friction (which is greater in cleated boots) cannot be ignored as a potential contributing factor to the aetiology of ankle injuries. The hypothesis being that had the injured players being wearing un-cleated footwear at the time of injury, they may not have sustained such injury, or the severity of the injury could have been minimized. It is not possible to substantiate such a hypothesis from the data obtained in our study as no players wore uncleated boots. However, research studies and anecdotal evidence from players suggest that such a hypothesis is possible.

The recent trend in hockey boots has been to construct boots with soles that have fewer, and smaller, cleats. The majority of the boots worn by players in the sample population at the time of our study had many more cleats, and the cleats themselves were bigger than those at present. The more popular brands of boots also used to have cleats protruding out sideways from the periphery of the boot. These are no longer present in the newer range of boots. Despite the fact that there are no clinical studies in hockey players proving that boots with fewer cleats reduce the risk of ankle injury, there does appear to be a shift towards wearing boots with fewer cleats.

5.2.3.3 External support and protective devices

The ability of finger guards to reduce the risk of finger injury will be discussed due to the high incidence of finger injuries. Finger guards were not used by most players. The finger guards that are available consist of webbed neoprene mitts, which only cover two thirds of the phalanges. They are primarily designed to prevent skin abrasions that develop when the player makes contact with the artificial turf whilst playing. Only 16% (36/222) of the players wore finger protection, with only 10% (n=2) of these players sustaining a finger injury. In contrast, 186 players (84%) did not wear finger guards, and 10% of this group sustained finger injury. This indicates that finger guards do not significantly protect against injury. However, the finger guards worn by the players were not specifically designed to protect against impact, but rather against abrasions.

The high incidence of hockey related finger injuries and the apparent lack of protection by the gloves that are currently worn by players indicates that there is a need to design a suitable protective glove that protects against injury but is also comfortable.

As was the finding with finger guards, it was also noted that the use of knee and ankle guards did not appear to decrease the incidence of knee and ankle injuries. However, there are limitations in interpreting these findings. As the side on which the player wore the particular guard was not noted, it was impossible to determine whether the injury at that site occurred on the side on which the guard was worn or not. A further limitation was the relatively small number of injuries at these specific sites, coupled with the small number of players using the protective and supportive devices.

## 5.3 Pre-season fitness assessment

### 5.3.1 Flexibility (Sit and reach test)

The players in this study achieved a mean sit and reach score (97±17 mm) that was marginally greater than that reported in a study of male South African club players (mean of 93 mm) (Scott 1991). However, the mean sit and reach score in male players in this study (87±16 mm), was less than the male players in Scotts' study (93mm).

Female players (109±18 mm) stretched significantly further than male players (87±16 mm). This supports findings of others who have shown that females have better flexibility than males (Alter 1988, Anderson 1988).

There was an association between age and flexibility, with players less than 25 years (105±16 mm), stretching significantly further than the players 25 or older (83±19 mm). This finding supports the hypothesis that with increasing age there is a decrease in flexibility (Seto and Brewster 1991). This decrease in flexibility with age has been attributed in part to the decreased elasticity of the collagen tissue due to an increase in the number of cross links between the fibres (Seto and Brewster 1991).

One of the postulated benefits of improved flexibility is enhanced athletic performance (Noakes 1987, Anderson 1988, Knapnik et al 1991). In our study, it was not possible to quantify hockey performance specifically, but performance could be measured with regard to the outcome of the three fitness tests. There was no correlation between the sit and reach results and the standing broad jump, 40 m sprint or the double winder. Therefore, the hypothesis that flexibility is related to performance was not supported by our study.

In summary, the hamstring flexibility of players in the sit and reach test was similar to that documented in other hockey playing populations. There was no significant relationship between poor flexibility and injury risk, and also no association between flexibility and the other fitness results (standing broad jump, 40 m sprint, double winder).

### 5.3.2 Muscle power (Standing broad jump)

The standing broad jump results, which measure muscle power, for the male players in this study (233 cm) were identical to those documented in a previous study of male South African club players (Scott 1991). A recent study of elite and league male South African hockey players showed that the elite players jumped slightly further (241 cm) than the league players (224 cm) (Sharratt 1995). Therefore, all the studies in which the standing broad jump data is recorded show similar results.

There was no significant difference in the standing broad jump distance in the various age categories. Players participating in pre-season training recorded a significantly further broad jump than those who did not engage in pre-season training. However, no particular type of pre-season training could be singled out as being most beneficial in this regard. There was also a significant correlation between the standing broad jump results and the 40 m sprint, as well as the double winder, with players performing well in the standing broad jump performing equally well in the other two tests. Reasons for this may be that the pre-season training benefited all the various energy systems, hence an individuals equally good performance in all three tests.

The standing broad jump requires a player to use predominantly the quadriceps and calf muscles. No quadriceps muscle injuries were recorded in the sample population during the prospective study, although four were reported in the retrospective study. This precluded any attempt to relate results in the standing broad jump to an increased susceptibility to injury for this particular muscle group. However, four calf injuries were recorded during the prospective study. There was no significant difference in the standing broad jump results of the players who sustained calf injuries and the players who did not. However, as the number of injuries recorded was small, the result must be interpreted with caution. However, there was a trend for players with shorter standing broad jump distances to be injured more frequently. This finding was similar to that documented by others (Dominguez 1978, Gruchow et al 1979, Fleck et al 1986), who showed that those with players with less than average muscle power appeared to sustain more injuries.

### 5.3.3 Speed (40 m sprint)

The results of the 40 m sprint showed that male players (5.0±0.3 sec) ran significantly faster than female players (5.7±0.4 sec) ($p=0.0001$). This was as expected, as it has been documented that men are faster than women over shorter distances (Noakes 1987). There was no correlation between running speed and risk of injury.

### 5.3.4 Muscle power (Double winder)

Male players recorded significantly faster times in the double winder test than the female players. Participation in a pre-season fitness program did not have as big an impact on the outcome of the double winder times as expected. A marginally significant faster double winder

1 time was noted in those players who participated in pre-season training. However, no such difference was evident in double winder 2 times. The finding that pre-season fitness had no significant effect on the outcome of an endurance test implies that the type of pre-season fitness undertaken may have been inadequate, and needs to be reviewed.

Our study showed that decreased endurance capacity (slower times in the double winder test) did not increase injury risk because there was no significant relationship between slower double winder times and injury risk. The results then do not support the hypothesis that decreased endurance capacity is a predictor of injury risk.

There was no significant correlations between any age category and the results obtained in the standing broad jump, 40 m sprint or the double winder test. The 25 - 29 year old players consistently dominated the majority of the tests, achieving the highest mean in all but one discipline, namely the sit and reach test.

### 5.2.5 Fitness tests results specific to player position

Earlier clinical studies of the physiological characteristics of hockey players documented substantial differences in the fitness test results achieved by players in different positions (Verma et al 1979, Kansal 1980, Bhanot and Sidhu 1983 Ready and van der Merwe 1986). More recent studies however, have failed to separate players according to position based upon their fitness test profiles (Reilly and Bretherton 1986 ).

In one of the earlier studies on field hockey physiology, it has been reported that the greatest difference in fitness characteristics could be observed between players in positions that are

distant from each other, that is, goalkeepers and strikers (Kansal et al 1980). In our study, in all but one of the fitness tests a significant difference between attack and defence orientated players was observed. The attacking players (strikers, midfielders) achieved the best results in every test (sit and reach test, standing broad jump, 40m sprint, double winder). It was thus possible to separate the players according to position, specifically attack or defence orientated players, on the basis of their fitness test results.

The sit and reach test was the only fitness test in which no significant difference was recorded between attacking and defending players. The greatest flexibility was recorded by the goalkeepers. This was not an unexpected finding as these players tend to concentrate on improving their flexibility because the nature of their play requires that they have the maximum range of movement. This allows them to reach as far as possible to provide maximum coverage of their goalmouth.

The attacking players jumped significantly further in the standing broad jump test (muscle power test) than the defending players, while goalkeepers recorded the shortest leap. It can be hypothesised that goalkeepers should perform well in the power test because the position requires that the player covers as much ground as possible in the shortest possible time. The ability to move, jump, lunge or dive quickly from a stationary position would be a definite advantage. The finding that goalkeepers recorded the shortest leap in this study was in contrast to the findings reported in a number of previous studies (Verma et al 1979, Kansal 1980, Bhanot and Sidhu 1983, Ready and van der Merwe 1986), which reported goalkeepers as having the greatest anaerobic power of all the positions. However, the test used in the afore-mentioned studies to measure power was the vertical stair run test, and this may account for the difference in findings. In one other study which was conducted in elite female English

players, similar standing broad jump results to those in this study were recorded. Strikers and midfielders performed better in the standing broad jump compared with defenders and goalkeepers (Bale and McNaught-Davis 1983).

The sprint capabilities (40 m sprint times) of the various positions decreased from the strikers to the midfielders to the defenders to the goalkeepers. The attacking players achieved significantly faster times than the defending players. This finding is not unexpected and reflects the type of activity that is required of the players in their respective positions. Attacking players have an advantage if they can sprint faster than defenders because they are able to run away from the opponent that is marking them. This enables them to receive a pass, or they can out-sprint a would-be tackler whilst in possession of the ball.

The effect of player position on endurance capacity (double winder times) was also investigated. The attacking players exhibited faster times than the defending players. It can be observed that midfielders usually perform the greatest amount of work during a game. They are the links between the strikers and defenders, so whether a team is on attack or defence, these players are always involved. It is therefore not surprising that the midfielders in our study recorded the best results for endurance capacity. A similar result was reported in a study among Canadian players. The midfielders in that study reporting the greatest oxygen-dependant capacity of all the positions tested (Ready and van der Merwe 1986).

Goalkeepers recorded the lowest endurance capacity. This was an expected finding as goalkeepers are not required to cover a great deal of ground during a match, and tend to remain in a small area of turf. It is therefore reasonable to assume that they do not depend heavily on their oxygen-dependent system. The findings of this study confirm the results of other studies (Verma et al 1979, Bale and McNaught-Davis 1983, Bhanot and Sidhu 1983,

Ready and van der Merwe 1986), showing that the attacking players (striker, midfielder) have the greatest endurance capacity, compared with the defending players (defenders, goalkeepers).

In summary, those players in the more attack orientated positions achieve consistently better results in the fitness tests (standing broad jump, 40 m sprint, double winder) than players with a predominantly defensive role. This finding is consistent with results recorded in a number of other studies of the physiological characteristics of hockey players (Verma et al 1979, Bale and McNaught-Davis 1983, Bhanot and Sidhu 1983, Ready and van der Merwe 1986). The results of our study do not confirm a recently proposed hypothesis that the nature of the modern game is such that it is no longer possible to determine a players position based upon their fitness test results, as the interchanging of position has resulted in a blurring of positional differences previously observed (Reilly and Bretherton 1986).

**Part II: The epidemiology of field hockey injuries**

5.4.1 Overall risk and incidence of injury

The seasonal risk of injury for players in this study was 0.59 injuries/player, and the incidence (injuries/1000 hours of play) of injury was 10/1000 hours. As no previous epidemiological studies of hockey injuries have recorded the true incidence of injury (expressed as injuries/1000 hours), it is not possible to state whether the incidence reported in our study is different from that observed in other hockey playing populations.

However, the incidence of injury in other sports has been reported. An epidemiological study of adult club rugby injuries documented an incidence of 1 injury every 171 playing hours (5.8/1000 hours) (Clark et al 1990). Although this is a lower incidence of injury than that reported in hockey, it is not possible to compare the two studies. The limiting factor that negates accurate comparison of the studies, is that a vastly different definition of the term "injury" was utilised in the rugby study (Clark et al 1990). In the study of rugby injuries an injury was defined as being one which precluded a player from participating in rugby for a period of seven days or longer after the time of injury. Thus the rugby study only documented more serious injuries, whereas our study documented injuries even if they resulted in no time off, provided that the injured player could not complete the match or practice, or required medical attention.

### 5.4.2 Match vs Practise

In this study, 85% of the injuries were sustained while playing matches and this is consistent with the findings of epidemiological studies of other sports. In a number of studies, it has been documented that the majority of injuries sustained during a season occurred in matches (Ekstrand and Gilquist 1983, Clark et al 1990, Stretch 1993).

This study showed that players were 14 times more likely to be injured during a match than a practise. The reasons for this are not clear, but it is well known that matches are highly competitive, with increased player motivation and aggression. Practises generally are associated with little competitive element and far less motivation or aggression. Also, a match is an hour of continued and concentrated activity, whereas practises are commonly broken into sections consisting of various drills with frequent rest periods in between.

### 5.4.3 Gender

Male players in our study were 1.2 times more likely to sustain injury than the female players. This finding is in contrast to the hypothesis presented by a number of researchers that females are more likely to suffer injury than males when involved in comparable exercise programs (Clark and Buckley 1980, Cox and Lenz 1984). A possible reason for male players sustaining more injuries than female players, is that on observation, men's hockey is more aggressive and of a physical nature in comparison to the women's game. Thus the increased injury risk of male players may be attributable to the way in which they play the game.

There were no statistically significant differences in the incidence of injuries sustained in the different anatomical regions between male and female players in the prospective study. However, one difference was noted in the retrospective study, with female players reporting significantly more finger injuries than male players. There was no apparent reason for this finding.

### 5.4.4 Age

There was no significant difference between the incidence of injury in any of the age categories. As no other study of hockey injuries has documented incidence of injury in terms of age, it is not possible to determine whether these results are representative of the hockey playing population in general. However, epidemiological studies of other sports (Ekstrand 1989, Clark et al 1990, Stretch 1993) do not demonstrate any particular trends with reference to age and injury, and it may be that hockey players fit this profile too.

The anatomical sites of injury were widespread amongst the various age categories, with no specific age category exhibiting significantly more injuries than any other. The only exception was in the 20 - 24 year old group who sustained the majority of finger (48%) and ankle (72%) injuries. There is no apparent reason for this finding.

### 5.4.5 Time of the season

The hockey season in South Africa starts in April and ends in October, with a break of approximately three weeks from the end of June to the middle of July. The months in which the highest number of injuries were recorded were May and August. Players were more likely to sustain injury at the beginning of the season or after the mid-season break. This observation is in keeping with trends observed in epidemiological studies of other sports, which also demonstrated this pattern (Ekstrand 1989, Clark et al 1990, Stretch 1993).

The increase in injuries at the beginning of the season could be attributed to a failure to participate in some form of pre-season fitness program, yet no such correlation was evident. In our study, there was no significant association between the particular type of pre-season training employed and predisposition to injury. It is important to consider that although it was noted whether or not a player participated in pre-season fitness, the magnitude of training was not investigated. This is an area which requires further investigation, as it may be that there was a difference in the amount of pre-season training done by each player, with the subsequent inference that those players who did less pre-season training were more likely to suffer injury than those who participated more regularly and over a longer period. Another reason for the high incidence of injury at the start of the season could be the lack of sport-specific fitness in the pre-season training, if indeed the player did train pre-season.

The increase after the mid year rest period may be due to a failure to maintain fitness or skills over the break, although this has not been investigated by any previous epidemiological study, and requires further investigation.

Injuries to specific anatomical sites were widely spread throughout the season and there was no apparent pattern. The only exception was injuries sustained to the lower leg and Achilles tendon which appeared to be more common during the first two months of the season. It was not possible to document whether or not these injuries could be linked to a lack of, or insufficient, pre-season training, because of the small number of injuries.

### 5.4.6 Player position

Although no previous epidemiological study of hockey injuries has documented the influence of player position on injury, epidemiological studies of other sports have been able to relate injury to position, with reference to both injury risk and incidence of injury (Roux et al 1987, Clark et al 1990, Stretch 1993). Our study found that the incidence of injuries was similar amongst the outfield players, with a lower incidence of injury reported by the goalkeepers.

Strikers sustained the highest injury risk (0.64 injuries/player) and incidence of injury (10.7 injuries/1000 hours) of all the positions. The position of striker is therefore the most dangerous position in field hockey. Strikers sustained mainly ligament sprains, and the most frequent mechanism of injury was tackling and open play on the ball. The finding that tackling was the predominant manner in which injury occurred was surprising, as tackling is often associated with being on the defensive, whereas a strikers purpose is to attack.

However, as none of the other epidemiological studies of hockey injuries have documented the mechanism of injury in depth, it is not possible to state whether or not such mechanisms are representative of all strikers in the general hockey playing population.

Midfielders recorded the second highest injury risk (0.6 injuries/player) and incidence of injury (10.16 injuries/1000 hours). Players in this position reported more muscle strains, fractures and tendonitis than any of the other positions. The three mechanisms that resulted in the greatest number of injuries were the lifted ball, open play on the ball and injuries of insidious onset.

The defending players are the halves and the sweepers. Players in these positions had the third highest injury risk (0.58 injuries/player) and incidence of injury (9.82 injuries/1000 playing hours). Defenders had the greatest number of head, groin and foot injuries of all the positions.

The two most common mechanisms responsible for the majority of injuries in defenders were injuries of insidious onset, followed by the lifted ball. The first of these mechanisms could be related specifically to defenders because the role of the defender requires a great deal of running. The lifted ball was also responsible for a high incidence of injury in defenders. It is common that the ball is lifted in the circle in an attempt to score. Defenders are required to protect their own goal and they are therefore exposed to the lifted ball.

Goalkeepers had the lowest injury risk (0.44 injuries/player) and incidence of injury (7.48 injuries/1000 hours). This was an unexpected finding as goalkeepers are often thought of as having the most dangerous position because the ball is hit at them, and they also have to dive to fend off the ball. A reason for the lower incidence of injury reported by the goalkeepers could be reflective of the small sample group (n=18). Also, goalkeepers are only involved in

the game for short periods of time when compared with the other playing positions. Another reason for the low incidence of injury may be that the protective gear is effective in decreasing the risk of injury.

The role of the goalkeeper is also unique because they are the only players that are permitted to use both their hands, as well as their body and feet, to play the ball. The nature of their play allows them to dive and log (lie in front of the goalmouth) in order to protect their goal. It was hypothesised that goalkeepers would have different anatomical sites of injury compared with other playing positions. Diving and logging can account for the high number of wrist and finger injuries sustained by goalkeepers, which amounted to 63% of the total injuries in this position. Goalkeepers sustained significantly more upper limb injuries compared to any of the outfield positions. The predominant mechanism of injury in goalkeepers was tackling and the lifted ball, and all the injuries occurred during match play. Goalkeepers sustained a significantly higher incidence of injury through tackling compared with the outfield players. The pressure and commitment in a match environment is much greater for a goalkeeper than any other position, as they are the last line of defence, and this may explain the high incidence of injury in goalkeepers during matches.

In summary, the incidence of injury was greatest in the attacking players, the strikers, and the incidence decreased as the player position was further away from the opponents goals. The goalkeepers had the lowest incidence of injury. All the playing positions reported similar injury sites, namely the fingers, ankle, knee and hamstrings. The exception was the goalkeepers, who sustained no ankle or knee injuries. The injury site and mechanism could sometimes be related to a specific player position. An example was the relationship of upper limb injuries in goalkeepers, coupled with the mechanism of injury. Goalkeepers may dive to the ground in an

attempt to clear the ball, and may injure their hand or wrist on landing, or be struck by a player during such a tackle. The ball can be lifted whilst in the circle, which may require the goalkeeper to use their hands to try and stop the ball, and in doing so, result in injury. The mechanism of injury could also be related to the specific activity of a particular playing position in defenders. Defenders suffer from injuries of insidious onset due to running and injuries related to the lifted ball. There was no anatomical site, type or mechanism of injury that was sustained significantly more in a specific player position. All the players were injured more in matches, with equal proportions of players in each position seeking medical attention.

### 5.4.7 Site of injury

The anatomical sites that were most frequently injures in our study were similar to those reported in other epidemiological research into field hockey injuries (Rose 1981, Jamison and Lee 1989). However, the distribution of injury between the upper and lower body varied from that reported in other epidemiological studies of hockey injuries (Rose 1981, Jamison and Lee 1989). In our study, 40% of the injuries sustained were to the upper body compared with 58-77% documented by other studies (Rose 1981, Jamison and Lee 1989).

#### 5.4.7.1 Head injuries

Head injuries were more common in our study than in the other epidemiological studies of hockey injuries (Rose 1981, Jamison and Lee 1989). The most significant mechanisms of head injuries were the lifted ball and tackling. Tackling resulted in injury when there was a clash of heads during a tackle, or when an opponent's stick struck the head. A contributing factor to head injuries may be a poor tackling technique, with a player attempting to tackle an opponent

from the left side. This requires further investigation. The predominant type of injury to the head region was a laceration (38%).

### 5.4.7.2 Upper limb injuries

The most frequent injury in the upper limb region was injury to the fingers, which was higher than that reported in other studies of hockey injuries (Rose 1981, Jamison and Lee 1989). The common mechanisms of finger injuries were as a result of the lifted ball and being tackled. Significantly more finger injuries resulted from these two mechanisms than any of the other mechanisms of injury. The fingers were traumatised between (i) the players stick and the ball, (ii) between the players stick and an opponents stick, or (iii) injured when the player used their hand to fend off a ball. A significant number of the injuries were fractures, with the remainder being joint effusions, lacerations and haematomas. The finding that a large percentage of the injuries were fractures (48%), highlights the importance of developing adequate protection for this area in hockey players. Finger guards presently used by the hockey players do not protect against finger injury.

### 5.4.7.3 Pelvis and lumbar spine injuries

Injuries to the pelvis and lumbar spine accounted for 13% of the total injuries. The most frequently injured anatomical area within this region was the lower back (7%). Lower back pain has been documented as a common injury in field hockey players. In one study of back pain in athletes, 7.6% of the patients seen at a sport-related lower back pain clinic were hockey players (Cannon and James 1984). In another retrospective survey of English clubs, 53% of the hockey players studied had at one time suffered from back pain (Reilly and Seaton

1990). It therefore appears that lower back pain is indeed common amongst hockey players, and this is supported by the results of our study. Two thirds of the injuries were of insidious onset (66%), with the remainder being of acute onset. Previous studies did not record the mechanism of injury, therefore it was not possible to compare the results of our study with the results of the other studies of lower back pain in hockey players.

The insidious onset of the majority of lower back pain in hockey supports the hypothesis that prolonged flexion changes the facet joint mechanics and causes local irritation, by inducing creep and thereby altering the internal axis of rotation. This results in lower back pain (Twomey and Taylor 1982). This process is thought to occur over a period of time, and this would account for the insidious onset of the injury. If indeed this is one of the causes of lower back pain, players should be advised of the benefit of frequent lumbar extension exercises, in an attempt to counteract the onset of creep. An additional benefit of this regular mobilisation into extension would be that the range of motion in the spine would be maintained.

The cause of lower back pain in hockey players has also been related to a decreased range of motion, particularly extension (Twomey and Taylor 1982). Lumbar extension exercise also stretch the psoas muscle. A specific stretch of this muscle may provide additional benefit. Crouching is a frequently adopted position in hockey, and involves lumbar and hip flexion. This position may contribute to an adaptive shortening of the psoas muscle. This could in turn affect lumbar spine mechanics because of the muscles attachment to the spine, as an inflexible muscle would restrict the normal range of motion in the spine. Further investigation of this hypothesis is required.

In summary, it was evident that the number of lower back injuries reported in this study was similar to that which has been reported by other studies of hockey players (Twomey and Taylor 1982, Cannon and James 1984, Reilly and Seaton 1990). Lower back pain is therefore a relatively common injury in hockey players, and is predominantly of insidious onset. Further clinical studies are needed to establish the exact aetiology of these injuries.

5.4.7.3 Lower limb injuries

The incidence of lower limb injuries was the highest of all the regions, with the ankle and knee joint and hamstring muscle being the most frequently injured sites.

The incidence of knee injuries reported in the prospective part of our study was similar to that recorded in the retrospective study, as well as other epidemiological studies of field hockey injuries (Rose 1981, Jamison and Lee 1989).

It has been hypothesised that the playing surface may contribute to the aetiology of knee injuries. Several studies of American football have shown that the rate of knee injuries is higher on artificial turf compared with grass (Larson and Osternig 1974, Bowers et al 1975). The findings of this study appear to reflect such a trend, with an incidence of knee injuries of 1.6 injuries/1000 hours recorded on artificial turf compared with 0.9 injuries/1000 hours on grass.

Artificial turf may be related to an increased incidence of knee injuries for at least two possible reasons. Firstly, there may be an excessive force transmission from the shoe-surface interface and secondly, artificial turf is less shock absorbing than grass. The shoe-surface interface is

believed to play a contributory role in the incidence of ankle injuries (Torg 1973, Torg 1974, Andreasson 1986). The knee, which is the next major joint in the kinetic chain, may be subjected to at least some of the stress incurred by the ankle joint. The stress attributable to shoe-surface interface would be torsional and is associated with sudden directional changes. This mechanism of injury would be observed during open play, on or off the ball. However, this was not the finding of our study, with significant numbers of injuries sustained by the player whilst being tackled. The injury thus resulted mostly from being hit on the knee by the opponents stick, or making contact with the opponent themselves. Transfer of excessive force from the shoe-artificial surface interface to the knee is therefore an unlikely explanation for the increased frequency of knee injuries whilst playing on artificial turf.

Artificial turf has been shown to absorb as much as 10% less energy than grass (Malhotra et al 1983). The ankle and knee might have to absorb increased shock and therefore be prone to overuse injury. However, the findings of our study also do not support the hypothesis that playing on artificial turf results in significantly more overuse injuries to the knee joint compared with grass. The incidence of intrinsic knee injuries was 0.4 injuries/1000 hours, compared with an incidence of 0.9 injuries/1000 hours for extrinsic knee injuries.

It is thus apparent that the nature of play accounts for most of the knee injuries, as opposed to the playing surface. Very little research data exists describing knee injuries in hockey and a great deal of research is required, as knee injuries are common (Rose 1981, Jamison and Lee 1989).

The ankle joint, together with the knee joint, was the second most frequently injured anatomical site in the lower limb. A similar number of ankle injuries were reported in other epidemiological studies of hockey injuries (Rose 1981, Jamison and Lee 1989).

The majority (89%) of the ankle injuries were sustained during matches on artificial turf. It has been reported that the increased incidence of ankle injury whilst playing on artficial turf is related to the greater fixation of the foot to the playing surface (Torg 1973, Torg 1974). The cleats fix the boot to the turf, and it is possible that the application of an external force may force the joint beyond its normal range of movement and result in a ligament sprain. In our study, the majority of players wore cleated footwear, and this has been implicated as a risk factor for ankle injury (Torg 1974). However, in our study, no particular brand or model of boot could be individually implicated in the predisposition to an ankle injury.

The hypothesis that ankle injury can result from increased "foot-fix" was weakly supported by the observation that ankle injuries occurred predominantly during open play, either on or off the ball. This phase of play is characterised by sudden changes in direction, whether it was to pass an opponent or turning sharply to attack/defend.

Ankle injuries were generally more serious and resulted in significant loss of playing time in the injured players. Most players missed at least one subsequent match or practice because of the injury.

Ankle injuries are both frequent and severe. Therefore, prevention of these injuries should assume greater importance. It has already been suggested that uncleated boots would probably help decrease the injury risk. A further recommendation would be the alteration of the hockey

boot from being a low-top shoe, to a high-top, similar to that used in basketball. Research has suggested that there is increased proprioceptive input by a high-top shoe (Petrov et al 1988). This increased proprioceptive input is believed to protect against ankle sprains (Barrett et al 1993, Shapiro et al 1994). Biomechanical studies have shown that high-top shoes also increase the mechanical stability of the ankle (Johnson et al 1976, Shapiro et al 1994). However, this increased stability of the ankle by wearing high-top shoes has not been shown in clinical trials. No well controlled studies have been conducted to date. It is thus an area which requires further investigation before a conclusive recommendation regarding the use of high-top shoes can be made.

Hamstring muscle injuries were the fourth most common injury (8%). Similar findings were not reported by other epidemiological studies of hockey injuries. These studies reported hamstring injuries as being 1-2% of the total injuries (Rose 1981, Jamison and Lee 1989). However, accurate comparison of our study with the other research is not possible because of the discrepancies in the methodology between them. The first epidemiological study was only of an inter-collegiate team which played solely on grass, thus both the level of competition and surface may have minimised such strains. The other epidemiological study was of a short duration and conducted over a tournament, which might have accounted for the different pattern of injury.

The mechanism of hamstring injury was open play on and off the ball in the majority of cases. Eighty two percent of the injuries were of acute onset. Hamstring strains often occur whilst sprinting, and it has been shown that sprinting is responsible for a high incidence of such injury (Lysholm and Wiklander 1987). During the last part of swing phase or at foot strike, the hamstrings generate peak torque values over the hip and knee that are greater than at any

other phase of the gait cycle, and contract maximally in an eccentric manner to decelerate the leg (Bruckner and Kahn 1993). Maximum torque generated when sprinting can explain the high incidence of sprint related hamstring injury, and hence the relationship of open play to hamstring injury.

A number of other predisposing factors have been linked to the etiology of hamstring injury, including abnormal biomechanics, muscle imbalance, training errors and poor flexibility (Bruckner and Kahn 1993). In our study, the relationship between flexibility and hamstring injury was addressed. In a number of studies of hamstring strains in soccer players and sprinters (Leimohn 1978, Ekstrand and Gilquist 1983), inflexible hamstrings were documented as an important aetiological factor. In a one year prospective study on soccer players, the relationship between inflexibility and hamstring injury was documented (Ekstrand and Gilquest 1983). In this study, 34 of the 44 players who sustained strains in the lower extremity had inflexible hamstring muscles. In a prospective study of sprinters with recent hamstring strains it was also documented that the injured players had significantly more inflexible hamstrings compared with uninjured sprinters (Jonhagen et al 1994).

The relationship between hamstring inflexibility and increased incidence of hamstring strains could not be confirmed by our study. There was no significant relationship between players who achieved poor sit and reach test results exhibiting an increased incidence of hamstring injury. It was possible that the small sample size (n=18) may have influenced this finding. Another factor may have been the method used to determine flexibility, which was the sit and reach test in this study. Although the sit and reach test has been documented as being both valid and reliable (Jackson and Baker 1986, Jackson 1989), others have advocated the use of the straight leg raise test (Cornbleet and Woolsey 1996). However, for large scale field testing the sit and reach test remains the easiest and quickest to implement.

Lower leg injuries in hockey players were only reported in one previous prospective study (Petrick 1993). This investigation reported that 27% of the players sustained a lower leg injury during the season. This was in contrast to the 5% of players (0.5 injuries/1000 hours) documented in our study. However, the results of these two studies cannot be compared because of the differences in the study populations, namely gender, age and level of play.

All the lower leg injuries reported were of insidious onset, 83% were classified as bone stress reactions (grade 1-3) and 17% as stress fractures (grade 4 bone stress injury). These types of injury can be related to mechanical overload of bone, and occur when the rate of microdamage exceeds that of repair (Bennel et al 1996).

It is important to note that all these injuries presented in the first half of the season. It is possible that a lack of adequate pre-season preparation may predispose players to such injury. However, no relationship between non-participation in pre-season training and increased risk of lower leg injury was documented. A more in-depth study of the particular type and duration of pre-season training that the players undergo is required.

In summary, in hockey players lower body injuries (pelvis and lower limb regions) predominated slightly over the upper body (head and upper limb regions) injuries. This finding was similar to that documented in other epidemiological studies (Jamison and Lee 1989). The common sites of injury were also similar to those documented by the other studies.

5.4.8 Type of injury

There was a higher incidence of muscle strains compared with ligament sprains or fractures. This finding differed from that reported in another study of hockey injuries over a tournament in which it was contusions, abrasions, lacerations and blisters that predominated at 64-90% of the total injuries (Jamison and Lee 1989). This can be attributed to the differences in the definition of the term "injury". In our study more minor injuries such as contusions, small lacerations and abrasions were not included in the injury definition. However, a study of hockey injuries over the duration of a tournament also documented muscle injury (5-12%) predominating over ligament injury (2%) (Jamison and Lee 1989).

The majority of muscle injuries in our study were to the lower body (93%), with the hamstrings (34%) and the lower back (28%) being commonly affected. A similar pattern was evident with the ligament sprains, in that 85% being sustained in the lower body. Sites most commonly affected included the ankle (67%), knee (15%) and wrist (15%).

Fractures occurred mostly in the fingers. It was possible to relate the combination of the site and mechanism of injury to the type of injury sustained. The fingers are frequently forcefully trapped between the ball and the stick, or between the players stick and opponents stick.

All the lacerations were sustained to the upper body, the majority being to the head region (72%). Lacerations were sustained only during tackling, or due to the lifted ball. They were thus caused by contact between a player and the ball, stick or another player. Although lacerations do not account for the majority of the injuries sustained, they could be substantially decreased by the use of protective gear. The use of a helmet would decrease the incidence of

lacerations to the head. If the helmet included a visor protecting the face, it could effectively eliminate all injuries to the head region, which at present accounts for 16% of all hockey injuries. An additional benefit would be that the players would no longer have to wear mouth guards, as the visor would protect this area. However, players would probably be reluctant to wear a helmet because of a perceived lack of comfort. Lacerations on the fingers could possibly be prevented by wearing finger guards.

### 5.4.9 Mechanism of injury

The most common mechanism of injury recorded in our study was tackling. Tackling resulted in a significant number of head and upper limb injuries. This finding is to be expected as tackling is an aspect of the game that involves contact between two players. The head and upper limbs are in close proximity during tackling, and this therefore explains the increased risk of injury to these regions. Another contributing factor could be that when players tackle from the "wrong" side, that is attempting to tackle from the opponents non-dominant side, they have a greater risk of being hit with the opponents stick.

Being tackled was a mechanism of injury that resulted in a significant number of upper and lower limb injuries. Individual sites affected were the fingers and the knees. Injuries can be caused by a player being hit by an opponents stick, or direct physical contact between a player and opponent as the opponent attempts to dislodge the ball.

Open play on the ball was a common mechanism of injury to the lower limb. The anatomical site that sustained the most injuries due to this mechanism was the ankle. Open play on the ball is characterised by the player moving with the ball, usually at speed. The action of sprinting in

itself has been shown to be attributable to injury (Lysholm and Wiklander 1987), but injury can also arise from a sudden directional change often occurring whilst the player is in possession of the ball. Open play off the ball also resulted in a significant number of lower limb and ankle injuries. The explanation is the same as for open play injuries on the ball.

The lifted ball is a common mechanism which was responsible for a significant number of head and upper limb injuries. The reason for the lifted ball affecting mainly the upper body is obvious. If the ball was raised below waist height, it is easier for a player to use the stick to protect themselves than if the ball is raised above the waist.

Injuries of insidious onset affected primarily the lower body, with the pelvic/lumbar and lower limb regions being significantly involved. As hockey is a game involving a great deal of running, it is possible that overuse of weight-bearing areas may occur. Another contributing factor may be the effect of the decreased shock absorption of the artificial turf (Malhotra et al 1983).

The mechanism of injury can also be classified in terms of extrinsic or intrinsic injury. An extrinsic injury resulted from external forces including the impact of the ball or stick, collision with another player, or a fall. Intrinsic injury resulted from internal strain on the body (Jamison and Lee 1989). A previous study of injuries incurred over a tournament over two successive years found that 82-88% of the injuries were extrinsic (Jamison and Lee 1989).This finding was also confirmed by our study, in which 81% of the injuries recorded were of an extrinsic nature. This is an expected finding in that hockey is a contact sport involving potentially dangerous equipment such as sticks and balls as well as entailing a degree of physical contact.

### 5.4.10 Severity of injury

Seventy percent of the injuries recorded in our study were severe enough that the injured player was not able to complete the game or practice. The implications of this are on both an individual/team and financial level, with either the team losing a valued player or the player incurring costs related to the treatment of the injury. Furthermore, it would be beneficial for the player and coach to have a basic knowledge of first aid (rest, ice, compression, elevation), so that the injury can be properly managed from the outset. It would be to the injured players advantage if ice was available at all matches. The majority of the clubs have clubhouses at their practice fields, thus ice should be readily available should an injury occur that practice.

The majority of injured players (68%) required medical attention. It was important to note that the three most frequently injured anatomical sites (finger, ankle, knee) were the three sites that required the most medical attention. This implies that these injuries were also of a more serious nature.

### 5.4.11 Playing Surface

Our study documented an incidence of injury of 13 injuries/1000 hours on artificial turf, which was significantly higher than the incidence of injury on grass (4 injuries/1000 hours). This finding supports the hypothesis proposed by various researchers that injuries occur more commonly on the artificial turf surface than on grass (Bortolin 1970, Larson and Osternig 1974, Bowers et al 1975, Malhotra et al 1983, Jamison and Lee 1989). An epidemiological study of hockey injuries in female players competing in the same tournament over two successive years also found that there were more injuries sustained on artificial turf than on grass (Jamison and Lee 1989).

It has been documented that the lower limb was more frequently injured than the upper limb, on both surfaces (Jamison and Lee 1989). The results of our study showed a similar finding. It could be hypothesised that the nature of the game results in this particular pattern of injury. The main activity in hockey is running, therefore the weight-bearing areas in the lower limb may be predisposed to injury as a result of this activity.

Patterns of injury were evident that appeared specific to playing surface. A significant finding was that all head injuries, and 97% of upper limb injuries, occurred on artificial turf. However, it was also significant to note that the majority of these injuries were sustained during matches. It was not possible therefore, to deduce from our data whether it was the game status or the playing surface that was responsible for the pattern of injury.

The comparison of injury rates of individual anatomical sites related to playing surface has been documented. In our study, the incidence of knee injuries was higher on artificial turf (1.6 injuries/1000 hrs), compared with grass (0.9 injuries/1000 hrs), but this was not statistically significant. This does not support with the findings of two prospective studies on injuries in American football, which reported that there was a significant increase in the rate of knee injuries on artificial turf compared to grass (Larson and Osternig 1974, Bowers et al 1975). Comparison of studies on different sports is, however, of limited value.

The predominant mechanism of injury on artificial turf was different to that on grass. The most common mechanism of injury on artificial turf was tackling and the lifted ball. On grass, the two most common mechanisms of injury were those of insidious onset and injury during open play, both on and off the ball. These was no clear explanation as to why the mechanisms of injury differed according to playing surface.

Another factor to consider in comparing the two playing surfaces is whether any difference was noted in the severity of injury on either surface. More of the players who were injured on grass (47%) could complete the practice/match compared with those players injured on artificial turf (27%). This may imply that the severity of injuries sustained whilst playing on grass was less than that sustained whilst playing on artificial turf. However, there no difference in the number of matches or practices missed due to injury on either surface, and similar numbers of players required medical attention for their injuries sustained on grass and artificial turf. Therefore, there was little difference in the severity of injury sustained on either surface.

In summary, the incidence of injury was higher on artificial turf, with significantly more head and upper limb injuries sustained on this surface. However, there were no significant differences between the severity of injury sustained whilst playing on either surface.

# Chapter Six

# CONCLUSION

The incidence of field hockey injuries (injuries/1000 hours) that was established during the 1995 hockey season was 10/1000 hours. As no other epidemiological study of field hockey injuries has documented the true incidence of injury (injuries per exposure hours), it was not possible to speculate whether the incidence recorded in this study was reflective of the general incidence of injury amongst other hockey playing populations. Due to discrepancies in methodology and terminology, it was not possible to correlate this data with that which was reported in epidemiological studies of other sports, for example rugby (Roux et al 1987, Clark et al 1990).

Certain variables, namely the players age and gender, were found to have no effect on the predisposition of a player to any specific injury site, type or mechanism of injury. However, a number of other variables (game status, time of season, player position, playing surface) could be related to an increased incidence of injury.

Significantly more injuries were recorded in matches compared to practices ($p=0.003$), a trend similar to that documented in epidemiological studies of other sports (Clark et al 1990, Stretch 1993). The highest incidence of injury was documented at the beginning of the season (Month 2 - 16 injuries/1000 hrs), as was reported in epidemiological studies of rugby, soccer and cricket injuries (Ekstrand and Gilquist 1983, Roux et al 1987, Clark et al 1990, Stretch 1993).

In certain instances it was possible to relate player position to the site, type and mechanism of injury. For example, goalkeepers sustained significantly more injuries to the upper limb ($p=0.001$), and significantly less injuries to the lower limb ($p=0.025$), than outfield players. This could be attributed to the style of play of the goalkeeper, which included diving, and using the hands to stop the ball.

The influence of the playing surface on the incidence of injury was notable. A significantly higher incidence of injury on artificial turf was recorded, compared to grass ($p=0.015$). This finding was similar to that documented in other epidemiological studies of both field hockey and other sports (Bortolin 1970, Bromwell 1972, Jamison and Lee 1989).

The anatomical sites most frequently injured in the field hockey players in this study, namely the knee and ankle joints (1.4/1000 hours) and the hamstring muscles (0.8/1000 hours), were similar to those documented by other epidemiological studies of field hockey (Rose 1981, Jamison and Lee 1989). The only exception was the high number ($n=21$) and incidence (1.6/1000 hours) of finger injuries reported in this study, a finding that was not recorded in the other epidemiological studies. The similarity between the findings of the various studies indicates that the results of this study could indeed be reflective of the injuries sustained by the hockey playing population in general.

The most frequent types of injuries recorded were muscular strains (2.4/1000 hours), ligament sprains (2/1000 hours) and fractures (1.7/1000 hours). The most common manner in which the injuries were sustained was during tackling (2.3/1000 hours) or were of insidious onset (2.0/1000 hours).

Important to note was that the four most frequently injured sites (fingers, ankle, knee, hamstrings) were those which sustained the most severe injuries, in terms of the number of practices or matches missed due to injury. Injuries to these particular sites therefore result in losses both to the team, in that a vital player may miss a match/s; and to the individual, who may lose their place in the team and may have to finance the medical treatment of the injury. Prevention of injuries to these specific sites thus assumes importance.

As a result of the small number of players using finger, knee and ankle guards in this study, it was not possible to establish whether these protective and supportive devices significantly reduced the risk of these specific injuries. However, in the absence of clinical studies, it is suggested that players use some form of finger protection due to the high incidence of finger injury, particularly as a significant number of finger injuries were fractures.

A potential aetiological factor in the epidemiology of ankle injuries was playing with cleated footwear on artificial turf. Most of the ankle injuries in this study were sustained during sudden directional changes, by players wearing cleated footwear. Research studies indicate that the risk of ankle injury can be reduced by wearing high-top shoes with fewer or no cleats (Torg 1973, Torg 1974, Johnson et al 1976, Andreasson et al 1986, Petrov et al 1988). The majority of the players in this study wore low-top boots with multiple cleats, therefore this hypothesis could not be clinically tested. However, based on the evidence of the research studies, it is possible to recommend that players should wear shoes with fewer cleats.

Hamstring muscle flexibility was the potential aetiological factor investigated in relation to hamstring muscle injury. However, there was no significant difference between the sit and reach scores of injured and non-injured players. Other factors which may be associated with hamstring injury include decreased hamstring muscle strength or muscle imbalance. These require further investigation.

Various risk factors are associated with injures in field hockey. There was no apparent relationship between the injuries players sustained in the previous season (1994), and the injuries that they sustained during the prospective study (1995). However, a longitudinal study over a longer period may reveal different results.

Surprisingly, participation in pre-season training did not decrease the incidence of injury, as there was no statistically significant difference between the overall incidence of injury, or site, type or mechanism of injury, between those players who did participate in pre-season training and those who did not. Also, pre-season training had no significant effect on the results of the pre-season fitness assessment, with the exception of the muscle power test. However, it was possible that the nature, type or duration of the pre-season training was not adequate, and this may thus have influenced the results. Further investigation of the pre-season training methods of hockey players is required.

It was possible to predict a players position based on the results of the pre-season fitness assessment, as attack-orientated players (strikers, midfielders) achieved significantly better results in the muscle power, speed and muscle endurance tests compared to the defence-orientated players (defenders, goalkeepers).

In summary, it is hoped that the descriptive data presented in this study will be supplemented by similar studies of other South African hockey playing populations, as well as being used as a data base for further, more analytical research into specific epidemiological or injury risk factors. Areas identified by this study that require more detailed investigation include pre-season training methods, pre-season fitness, protective/supportive devices and footwear.

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# APPENDIX

**Contents**

**Appendix 1**

Player profile questionnaire

Name:_____ Age:_____

Telephone number:_____(H)_____(W)

1. Playing position
   (a) Striker _____ (1.1)
   (b) Midfielder _____ (1.2)
   (c) Defender _____ (1.3)
   (d) Goalkeeper _____ (1.4)

**INJURY HISTORY**

2. List all the hockey injuries which you sustained in the previous season (1994)
   (a)_____ _____ (2.1)
   (b)_____ _____ (2.2)
   (c)_____ _____ (2.3)
   (d)_____ _____ (2.4)

**TRAINING**

3. Do you participate regularly (twice a week or more) in any sport other than hockey during the hockey season? If yes, please specify:_____

4. Do you start getting fit prior to the start of the hockey season? Yes _____ (4.1)
   No _____ (4.2)

5. What does your pre-season training include?
   (a) running _____ (5.1)
   (b) cycling _____ (5.2)
   (c) gym _____ (5.3)
   (d) Other _____ (5.4)
   (Specify:_____)

6. Do you stretch? Yes _____ (6.1)
   No _____ (6.2)

7. If yes, when do you stretch
   (a) before playing _____ (7.1)
   (b) during play _____ (7.2)
   (c) after playing _____ (7.3)

8. How long do you maintain the stretched position for?
   0-5 sec _____ (8.1)
   6-10 sec _____ (8.2)
   11-15 sec _____ (8.3)
   16-20 sec _____ (8.4)
   > 20 sec _____ (8.5)

9. How many times do you repeat each specific stretch? | 1 | 2 | 3 | 4 | 5 | >5 | (9.1-6)

**EQUIPMENT**

10. Do you use a gum-guard when playing hockey? Yes _____ (10.1)
No _____ (10.2)

11. If yes, when do you wear it?
(a) Matches only _____ (11.1)
(b) Practices only _____ (11.2)
(c) Matches and practices _____ (11.3)

12. What type of footwear do you play hockey in?
(a) Hockey boots _____ (12.1)
(b) Running shoes _____ (12.2)
(c) Other (specify)_____(12.3)

13. If you wear hockey boots, please indicate the
(a) brand (make) _____(13.1)
(b) model_____(13.2)

14. Do you wear any of the following supportive or protective devices when playing hockey?
(a) Shin pads _____ (14.1)
(b) Finger guards _____ (14.2)
(c) Knee brace _____ (14.3)
(d) Ankle brace _____ (14.4)
(e) Other(specify)_____ (14.5)

## Appendix 2

Pre-season fitness assessment

The pre-season fitness assessment consisted of the following tests:

1. Sit and reach test (flexibility) - measured in mm
2. Standing broad jump - measured in cm
3. 40 m sprint - measured in seconds
4. Double winder - measured in seconds

**Appendix 3**

**INJURY REPORT FORM**

1. Name: _____ 2. Club: _____

3. Position _____ 4. Date of injury ____/____/____

5. Anatomical site of injury: _____

6. Type of injury:

| | | | |
|---|---|---|---|
| Muscle strain ____ (6.1) | | Ligament sprain ____ (6.2) | |
| Fracture | ____ (6.3) | Haematoma | ____(6.4) |
| Effusion | ____(6.5) | Laceration | ____(6.6) |
| Tendonitis | ____(6.7) | Concussion | ____(6.8) |
| Fasciitis | ____(6.9) | Bursitis | ____(6.10) |
| Bone stress reaction ____(6.11) | | | |

7. Mechanism of injury:

| | |
|---|---|
| Tackling | _____(7.1) |
| Being tackled | _____(7.2) |
| Open play, on the ball | _____(7.3) |
| Open play, off the ball | _____(7.4) |
| Foul play | _____(7.5) |
| Insidious onset | _____(7.6) |

8. Injury occurred during Match _____(8.1) Practice _____(8.2)

9. Playing surface Artificial turf _____(9.1) Grass _____(9.2)

10. Did player complete match/practice? Yes ____(10.1) No ____(10.2)

11. Matches/practices missed due to injury? _____

12. Did injury require medical attention? Yes ____(12.1) No ____(12.2)

13. Which medical professional was consulted? _____

14. Were any further medical procedures/investigations undertaken? Specify?_____

**Appendix 4**

**TESTING DATA SHEET**

**Club:** _____ **Date:** _____

| **Name** | **Sit and Reach test (mm)** | | | **Standing broad jump (cm)** | | **40 m sprint (sec)** | | **W 1* (sec)** | **W 2^ (sec)** |
|---|---|---|---|---|---|---|---|---|---|
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*: W 1 = winder 1

^: W 2 = winder 2

**Appendix 5**

Sit and Reach Test

Instrumentation

A standard sit and reach box was used for the testing. It consisted of an upright board along which a ruler (marked in mm) was fixed. At the zero point on the ruler, the board was bisected perpendicularly by a foot-plate. The zero point on the ruler thus reflects the position where the players fingertips are level with their feet (Figure 3.27).

Procedure

The subject sits on the ground in the long-sitting position, with the knees fully extended. Both feet are placed on the foot-plate, ensuring that the ankles are in neutral dorsiflexion. The subject is instructed to place one hand on top of the other and reach forwards along the ruler as far as possible. The reading is taken from the ruler at the point where the subjects fingertips reach (in mm). The reading will be a negative number if the subject fails to reach beyond their toes, or a positive number if they do reach beyond their toes. Each subject is tested three times, with the average of the three readings being recorded.

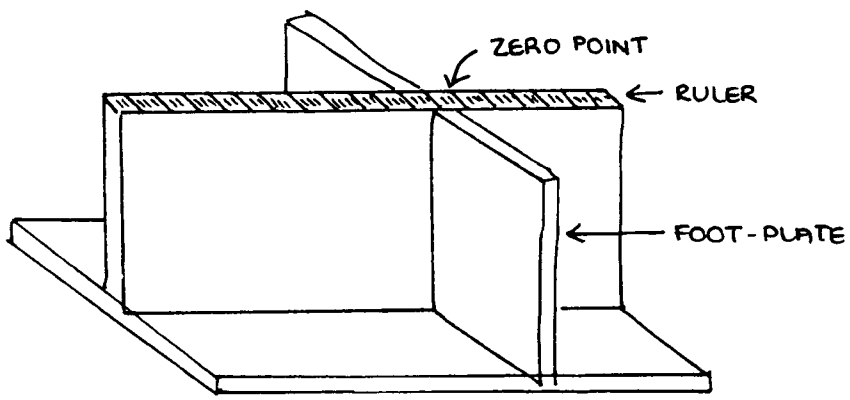


Figure 3.27 Sit and Reach box

## Appendix 6

Standing Broad Jump

Instrumentation

A start line is constructed using a 1 m length of rope fixed tightly between two pegs. The distance jumped is measured using a standard measuring tape.

Procedure

The subject stands with feet parallel so that the tips of both boots just touch the start line. The subject jumps as far forward as possible from this standing start, and remains stationary on landing. The distance (in cm) is measured from the start line to the heel of the foot closest to this line. The test is repeated twice, with the average of the two jumps being recorded.

**Appendix 7**

40 Metre Sprint

Instrumentation

A distance of 40 m is measured on the hockey field using a measuring tape. The start and finish marks are represented by beacons. The time taken to complete the distance is measured using a stopwatch.

Procedure

The subject has a stationary start from level with the first marker. The starting instruction given by the tester is "get set, go", at which point the tester starts timing. The subject runs the distance as fast as possible. The tester stands level with the finish beacon and stops the stopwatch as soon as the subject passes this point. The average of two tests is recorded, with a 2 minute rest interval between each test.

**Appendix 8**

Double Winder

Instrumentation

This test is performed on a properly marked standard hockey field. The time taken to complete the test is measured during a stopwatch.

Procedure

This test can be performed in a group. Subjects perform the test whilst carrying their hockey sticks, and are instructed to complete the test in the shortest possible time. The subjects line up on the baseline. The starting instruction given by the tester is "get set, go", upon which timing commences. The subjects run to the 25 m line, bend and touch it with either hand, and return to the baseline, also touching it. They then proceed to the 50 m line, touch it, and return to the baseline. Similarly, they run to the 75 m and 100 m (opposite end of the field) lines respectively. On returning from the 100 m line, the test continues in the reverse order. The subjects thus return a second time to the 100 m line, and then wind down to the 75 m, 50 m and 25 m lines respectively (Figure 3.28). Their times are read out by the tester as they cross the baseline after the final return from the 25 m line. These times are recorded.

A four minute rest is given, after which the test is repeated in the same manner. The time taken to complete the second winder is also recorded.

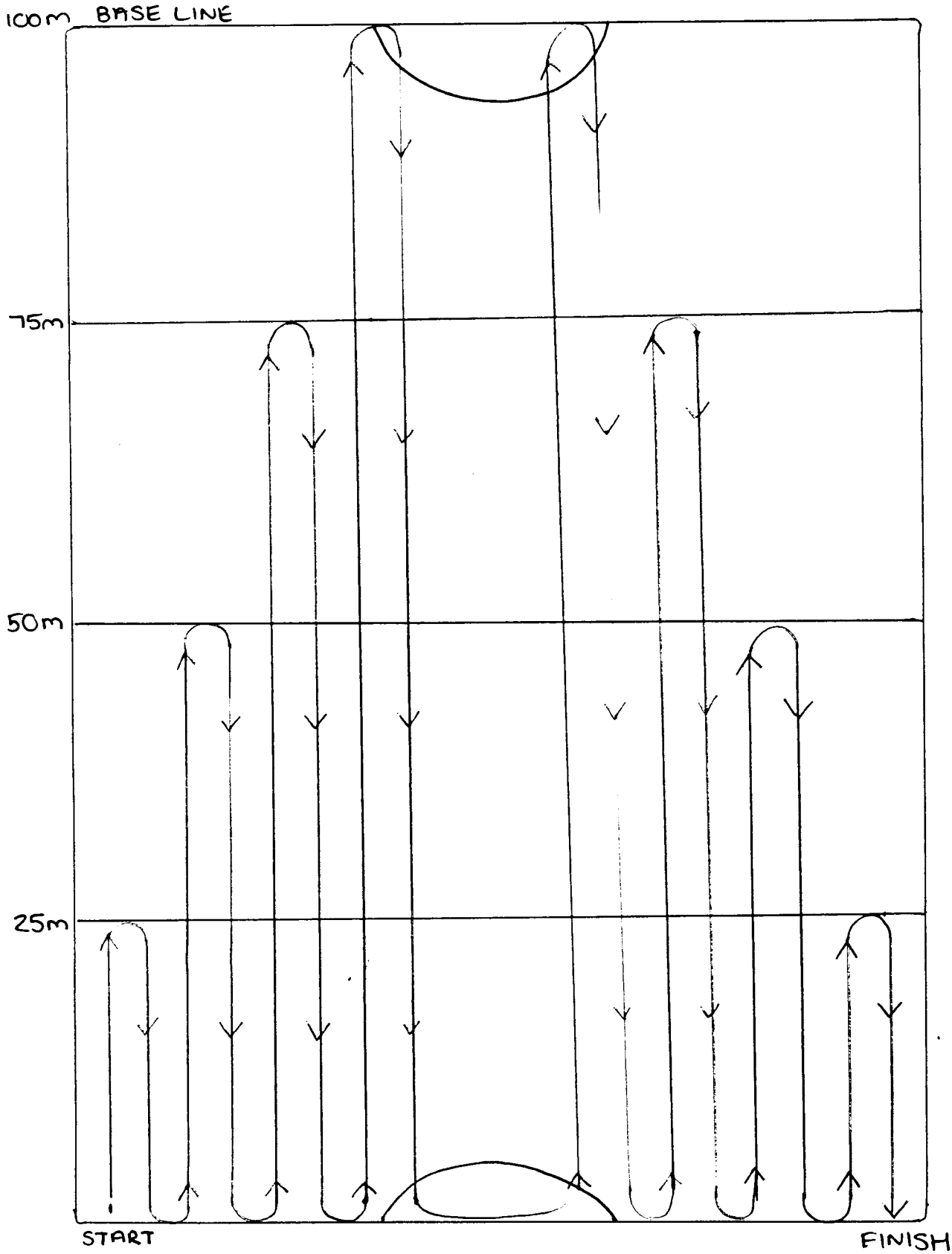


Figure 3.28 Double Winder