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MD thesis

THE MECHANISM AND PREVENTION OF INJURY IN SOCCER

by

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DECLARATION

I hereby declare that this thesis has been composed by myself, that it has not been submitted in any previous application for a degree, that except as acknowledged the work has been carried out by myself, that the general matter of the thesis is my own general composition, and that I have distinguished all quotations by italics and specially acknowledged sources of information.

No benefit in any form has been received by the author from any commercial party towards this thesis, and any contribution made for copies of this thesis will solely be used to meet the costs of publication.

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SUMMARY

The study was designed to provide an overview and a unique insight into the musculoskeletal demands of the professional footballer in Scotland.

The retrospective assessment of 462 players identified 78 (17%) who had previously required knee surgery. Further analysis confirmed that the majority (44) required partial medial meniscectomy and that only one meniscal repair had been attempted. A relatively small subgroup of players (8) required anterior cruciate reconstruction which is considerably lower than any European based study. Player position, contrary to previous soccer epidemiology, could be a relevant factor with the majority of knee operations being performed upon defenders and goal keepers (Chi-squared=14.735, df=3, p=0.002). There also appeared to be a surgical bias, according to the level of competition, with surgical reconstruction occurring more frequently within teams from the higher divisions.

The preseason is a traditional period, averaging four to six weeks, which precedes the start of each competitive season. This prospective study of sports injuries during the preseason period of the Scottish Football League season 1993-1994 was undertaken; 480 players from 27 clubs were assessed. Twenty four of the 27 clubs recruited completed the study. Of the 414 registered players, 123 (> 1 in 4) reported significant injuries. An injury was described as an event occurring during a scheduled training session or a match, which caused the player to miss the next game or training session, within the following 72 hours. Of the injuries reported, 53.7% were non contact injuries and principally involved the thigh (14), achilles/ankle (12) and groin (9), respectively. Of these non contact injuries, 1 in 3.5 were recurrent and 3 injuries (2 groin and 1 achilles) subsequently required surgery. Of those remaining non contact injuries, 50% (34) sustained a subsequent injury during the first 12 weeks of the season. Thirty percent of the second injuries were recurrent preseason injuries and 9 (25%) of

these players had more than 2 significant injuries during the first three months of the season.

It can be concluded that preseason training, although non competitive, is a period of high risk and its contents must be re-examined. Emphasis should be placed on injury prevention, especially from overload and overuse injuries, to ensure peak performance and team stability. Further research into aspects of overtraining during this period is required.

Assessments were performed on 480 players from 27 clubs, on a weekly basis, for the entire 40 weeks of season 1993-1994. Twenty clubs successfully completed the period of study and the results were analysed in detail. A total of 677 injuries were reported for 342 players. This resulted in an average of approximately 2 significant injuries per player per season, the majority of which were non contact (322), although contact injuries accounted for a similar number (307). The most vulnerable areas included the ankle (144), the upper leg (128), the knee (117) and the groin (71). There was a slight seasonal pattern to the weekly injuries reported, with an increased number of contact injuries, especially from tackling, occurring during the first 15 weeks and a peak of non contact injuries during the first four weeks of the season. This may well relate to the excessive demands of the preseason period. The commonest injuries included ligament strains (164) followed by muscular strains (99). These two pathologies have now clearly been identified as targets for preventative measures. It is clear from this study, that an understanding of the mechanism of injury is important, if preventative measures are to be targeted effectively. Contact injuries, were responsible for the majority of ligament sprains (89) and ligament tears (19). These ligament injuries predominantly involved the ankle and were often the result of tackling (64). Non contact injuries predominantly resulted in muscular strains (134). They were also responsible for a large number of ligament sprains (68) and tendinitis (43); The latter frequently involved the Achilles tendon (30). These non contact injuries are often preventable, as they result from overuse and overload or incomplete rehabilitation after previous injury. This, in essence, offers a tremendous opportunity for the medical team and coach to intervene.

Interestingly, contrary to popular opinion, there was very little variation in the incidence and type of injury according to the level of competition (Chi-squared=1.533, df=1, p=0.216). The Premier group had approximately twice the level of back injury (19) and a higher incidence of upper leg injury (68), when compared with the lower divisions. Lower leg and groin injuries did not differ between the groups. Ankle injuries predominated in the lower divisions (65) as compared to the Premier group (51). Eighty-five percent of the Premier players and 79% of the players in the lower divisions sustained an injury during this season. The level of injury recurrence, which is a reflection on the rehabilitation process, was slightly higher in the lower divisions (18.7%) compared with the Premier group (16.6%). The surgical requirements according to the level of competition were very similar, the only significant difference being that two Achilles operations were required on players from the Premier group and none on those from the lower divisions.

Match injuries accounted for the majority of soccer injuries in this study (77%). The remaining 23% of injuries occurred during training sessions. Surprisingly, 54% (203) of the match injuries did not require immediate substitution. This gives rise to concern, as all injuries reported were significant enough to prevent the individual from participating in the following training session or match. For this reason the mechanism of injury was assessed in detail. Thirty six percent of these match injuries occurred without contact. This is not surprising as non contact injuries are often progressive and gradual in onset. However, the remaining 64% of these players sustained contact injuries for which substitution and early medical attention would have been more appropriate.

One in 10 of all injuries required hospital referral. The majority of these injuries (77%) occurred during a competitive match and 12% (46) of these required hospital assessment and treatment. Knee injury was the commonest reason for hospital referral (19). Eight ankle injuries also required hospital treatment, all after direct contact and no operative internal fixation was required. Ten players required hospital assessment for head and facial injury.

The essence of sports medicine is to prevent injury and its recurrence. In this study injury recurrence accounted for 19% (121) of the 644 injuries reported during season 1993-1994 (34 not specified). As approximately 1 in 5 injuries were recurrent, it is important to study the injury mechanism in detail. Remarkably, 74% (89) of the recurrent injuries were non contact and not related directly to the physical contact associated with soccer. Fourteen percent (17) of the recurrent injuries resulted from tackles. Recurrent injuries should remain a priority for the medical team, as the majority are non contact and relate to overload and overuse of tissues. This may result from a physiological weakness from previous injury or be due to the persistent overload associated with competition and training.

Muscular injuries accounted for 34% (41) of recurrent injury pathology, followed closely by ligamentous injuries, representing 31% (37). Treatment and rehabilitation should be focused on muscular strains (28%), ligament sprains (25%) and tendon inflammation (17%), as these pathologies clearly represent the most common causes of injury recurrence. By anatomical region, 15% of ankle injuries (27) gave rise to recurrent pathology and 26% (31) of knee injuries. Player position does not predispose to injury recurrence, although goalkeepers are less prone to recurrent injury. It is worth noting that 121 recurrent injuries were shared between 86 players and therefore 17% (15) of the players sustained two or more injury recurrences. There is also a slight seasonal pattern to injury recurrence, with 31% of recurrent non contact injuries occurring during the first quarter of the season, followed by a definite dip in injury frequency over the festive period. The initial seasonal peak may well relate to the resultant effects of a poorly structured preseason and the Christmas dip may relate to extreme weather and match cancellation.

During season 1993-1994, 30 players (8.8%) required surgery and shared a total of 33 operations. Almost 1 in 10 players, therefore, required surgery during the season with all that entails. Not surprisingly, knee surgery was the commonest procedure, with 13 operations being performed on 11 players. Two players initially had arthroscopic examinations and subsequently required further reconstructive procedures. Surprisingly, the next most frequent operation was that of groin or hernia repair (6). Interestingly, 68% (23) of injuries requiring surgery during season 1993-1994 occurred during training, rather than as a result of a competitive match. This was confirmed when the mechanism of injury was assessed in detail, as 25 (75%) of injuries which required surgery were non contact. Of the 14 players requiring knee surgery, it is of concern that 6 (44.8%) of these players had previously required knee surgery, although ther was no strong statistical evidence of an association (Fisher's exact test, $p=0.094$). Of the 342 players studied for the full season, 56 had reported previous knee surgery. Therefore, 19% of players who had previously had knee surgery required further surgery which would merit further research. There was also no strong evidence that the proportion of players requiring surgery differs for the different positions (Chi-squared=4.446, df=2, $p=0.108$).

This study has provided a unique insight into the musculoskeletal demands of professional football. The mechanism and prevention of injury in soccer, has been studied in detail. This will provide a rational basis for future planning in the hope of optimising performance and minimising injury and its recurrence in soccer.

1. INTRODUCTION

Hippocrates who witnessed the birth of the professional athlete at the Panathenaic Festival stated that," the condition of the athlete is not normal".

Prevention of illness and disability is the renewed focus of modern medicine and a continued focus for Sports Medicine. This statement is supported by the World Health Organisation and reflected by the priority given to the working group on "Sports for all: sports injuries and their prevention." To reach these objectives sports specific research is required to analyse the incidence, type and location of injuries, as well as the mechanism behind these injuries. The final step in such a sequence of prevention, would be to introduce measures likely to reduce the likelihood and severity of injury. (Van Mechelan *et al*, 1987).

Soccer remains the most popular sport in the world, with approximately 40 million organised players and is responsible within Europe for between 50 to 60% of all sports injuries and 3.5 to 10% of all hospital treated injuries. (Frank, 1977, Ekstrand, 1982, Keller *et al.* 1987). The epidemiology of injury in Scottish football and in the British game generally remains open to debate and largely based on pseudo-science. Although the evidence is largely anecdotal, it appears to be a popularly held opinion, sustained by the press, that the frequency and severity of injury in soccer is on the increase. Various reasons have been suggested for this including; the number of matches played, the extremes of our winter climate or the manner in which the game is played in Britain. Yet the perennial problems of soccer injuries continue to undermine individual team and national aspirations and cause untold misery for the unfortunate individuals affected..

Although soccer has been our national sport in Scotland for over 100 years, since the Scottish Football League was formed in 1890, there has been remarkably little sports specific research addressing the injury problems relating to the game. The epidemiology of soccer injuries has been studied by several authors (e.g. Roaas and Nilsson, 1979; McMaster et al, 1978; Ekstrand, 1982-1983; Albert, 1986; Nielson, 1989; Engström, 1991; and Aglietti, 1994). The incidence they report ranged from 4 to 7.6 injuries per player per 1,000 hours of play, with the lower extremities representing between 64% and 93% of all injuries.

This brief summary simply summarises a review of the International literature, but its application to the British game is seriously flawed. The literature published to date includes a mixture of player of different ages and levels of competition, in environments which are often radically different from those in which the British game is played. There was a clear need to establish a large prospective study of sports injuries in professional football in Scotland, to provide evidence for further rational debate on injury prevention and to help focus further research. The benefits of such a study would clearly filter down to all levels of the game.

Confidentiality and co-operation has traditionally been a major obstacle for anyone wishing to undertake such a study. As a former professional player, I was in the fortunate position of being able to appreciate the concerns of individual clubs. I eventually obtained the support of twenty-seven soccer clubs, each represented by 18 players, who were assured of complete confidentiality. This thesis was planned to answer several crucial and as yet unanswered questions.

(a) to establish the frequency of soccer injury.

(b) to identify the mechanism of injury in particular whether contact or non-contact.

(c) to establish the anatomical regions most frequently affected.

(d) to identify any associations between injury and player position, level of competition or age.

(e) to address the problem of injury recurrence.

(f) to make a broad assessment of the needs for sports related orthopaedic provision.

It was hoped that if these questions could be answered satisfactorily, then we would be in a more informed position when discussing possible league restructuring, which might include; altering match frequency or introducing a winter break.

Base line information was obtained on all 480 players, who were assessed by club doctors and physiotherapists. This included retrospective data, relating to any injuries which were being carried forward from the previous season and a record was established, of players who had previously required knee surgery. The second phase of the study, was designed to assess the impact, whether favourable or otherwise, of the traditional Scottish pre-season period, which lasts between 4-6 weeks before the season formally commences. Players were then assessed on a weekly basis, prospectively for the whole of Season 1993-1994, to establish the frequency, aetiology and severity of injury and how this might relate to; position, player age, level of competition and previous injury or surgery. An attempt was also made to establish whether injuries arose during competitive matches or training, whether due to contact and to establish if injury recurrence was a problem. The specific anatomical region affected, was also examined in detail.

In conclusion, the importance of sports injury prevention, cannot be over emphasised. This study will provide an overview and a unique insight into the musculoskeletal demands of the professional footballer in Scotland.

CHAPTER 2. REVIEW OF LITERATURE

2.1. History

2.1.1. The Development of British Football: Aggression and Injury Prevention

What is football? Football is a generic term which refers to the whole class of ball games, central among which is Association Football or Soccer. In fact, Soccer itself is a corruption of the term Association. The origin of football is shrouded in mythology and it is clearly difficult to extract the historical facts from the folklore (MacKay and McConnell, 1994a).

Origin

A possible origin of football was described by W B Johnson in 1929 (Dunning, 1994). This involved the pagan fertility rite in which the ball represented the bringer or giver of life, viz. the sun; (La Soule, is the French for the traditional game). Although, there indeed appears to have been a heterogeneous origin, the Haxley Hood game, which survives in Lincolnshire captures graphically the inherent aggression with which part of the sacrificial beast (the ball) was pursued. Traditionally the game is kicked off by the Fool's speech;-

> 'Hoose again hoose, toon again toon,
>
> And if you meet a man knock him doon'.

Clearly this game was a violent and enjoyable sublimatation for expressing conflict between rival groups (Dunning, 1961).

Evidence for the existence of football in the UK can clearly be traced to the 14th Century (first recorded reference: 1314); indeed statutes prohibiting football were frequently issued. Basically such vain games were considered to have no part in the defence of the realm and, along with similar sports, were described as unthrifty and idle games (Marples, 1954).

Essentially football continued to remain closely entwined with the military structure although fulfilling different roles to which we shall elude. The Acts of Parliament of Scotland 1424-1707, (published by HMSO: 1966) clearly finds expression for King James I's frustration at the youth of the nation who were more interested in football than military pursuits; in particular archery. The Parliament of Scotland, at Perth on the 26 May 1424 banned football several days after James I was crowned at Scone.

> ACT 18
>
> 'Then, it is decreed that the King forbids that any man play football under the penalty of fourpence to be summonsed to the lord of the land as often as he is convicted, or to the sheriff of the land or his ministers if the lords will not punish such trespassers'. (MacKay and McConnell, 1994b).

This may have been encouraged by the fact the Earl of Buchan with a Scots army of 7,000, defeated the English at Beauge in 1421, after indulging in a pre battle football match.

The Football Association

The Football Association (F.A.) emerged in the 1850's as the middle class expanded with urbanisation and industrialisation (Dunning, 1994) and with the aim of giving structure to the "public school games cult" and the Scottish Football Association followed in 1873. It was during this phase that football clearly diverged into the rival associations of rugby and football. The conflict was clearly highlighted on the 1 December 1863 as contentious draft rules were discussed. With reference to "hacking", the Secretary Elect, EC Morley, said that he personally did not object too strongly to "hacking" but to retain these rules would seriously inhibit the development of the game. Those supportive of the rugby code, suggest that "hacking" was an essential element of pluck and its removal would "emasculate" football.

First World War

During the 1st World War there was a crusade against football as stated by a telegram sent to the King by Mr F N Charrington, the East End Temperance worker in 1914. He said:-

> "May it please your Majesty to remember that Lord Roberts recently said it would be disgraceful if football was continued during the war. The F.A. have now decided to continue their matches, despite all protest. Your Majesty has set an example to the Nation in sending your two noble sons to the Front."

He then continued to question the resulting position of his Majesty, as patron of the F.A. In response, Lord Standordham, his Majesty's Lord-in-Waiting, writing from Buckingham Palace on 5 September stated:-

> "I gather that the F.A. are in direct communication with the War Office, and a general desire has been expressed by the Association to assist in obtaining recruits for the army."

Indeed football stadiums were useful recruiting grounds where pressure could be brought to bear upon young men demonstrably, "A1 but not yet in khaki."

By the end of 1914 it was estimated that 500,000 men had been recruited at football matches. Professional footballers were urged by Mr Punch and others to enlist, "Join and be in THE FINAL and give them a KICK OFF THE EARTH." Eventually Charrington finally succeeded in getting professional football officially banned in Spring 1915 and players were urged to be reconciled on the field of battle. (Parker, 1987).

Aggression

In contrast, up to mid 1915 the War Office manual continued to stress the importance of games in the course of prospective officer selection; this course lasted just one month with final selections being made on the basis of games of rugby and soccer, according to the respectability of the violence displayed and the quickness of reaction generally. This position may have been based on the traditional respect afforded to strength and sporting prowess by the military, in particular recruits. Behavioural studies support this approach; the personality factor test of Cattell (1965), identified physically gifted individuals in terms of extrovert tendencies such as: dominance, social aggression, leadership, tough mindedness, low anxiety and high confidence. It is also suggested that a high level of sporting performances may be associated with a more aggressive personality and indeed in many games the aggressive value of behaviour is both obvious and sanctioned by the rules of the game. (MacKay and McConnell, 1994a).

Enthusiasm for sport continued at the Front during World War I, where games were deemed suitable recreation for the troops (Fig. 1). These games were usually very physical, for example, Allhusen remembered an inter-battalion match in Salonika for officers in which two of the opposing sides were carried away on

TROOPS IN SALONIKA

stretchers - The match was eventually halted by the Brigadier who objected. Despite this, by the end of 1917, soccer became compulsory and was played with army issue footballs.

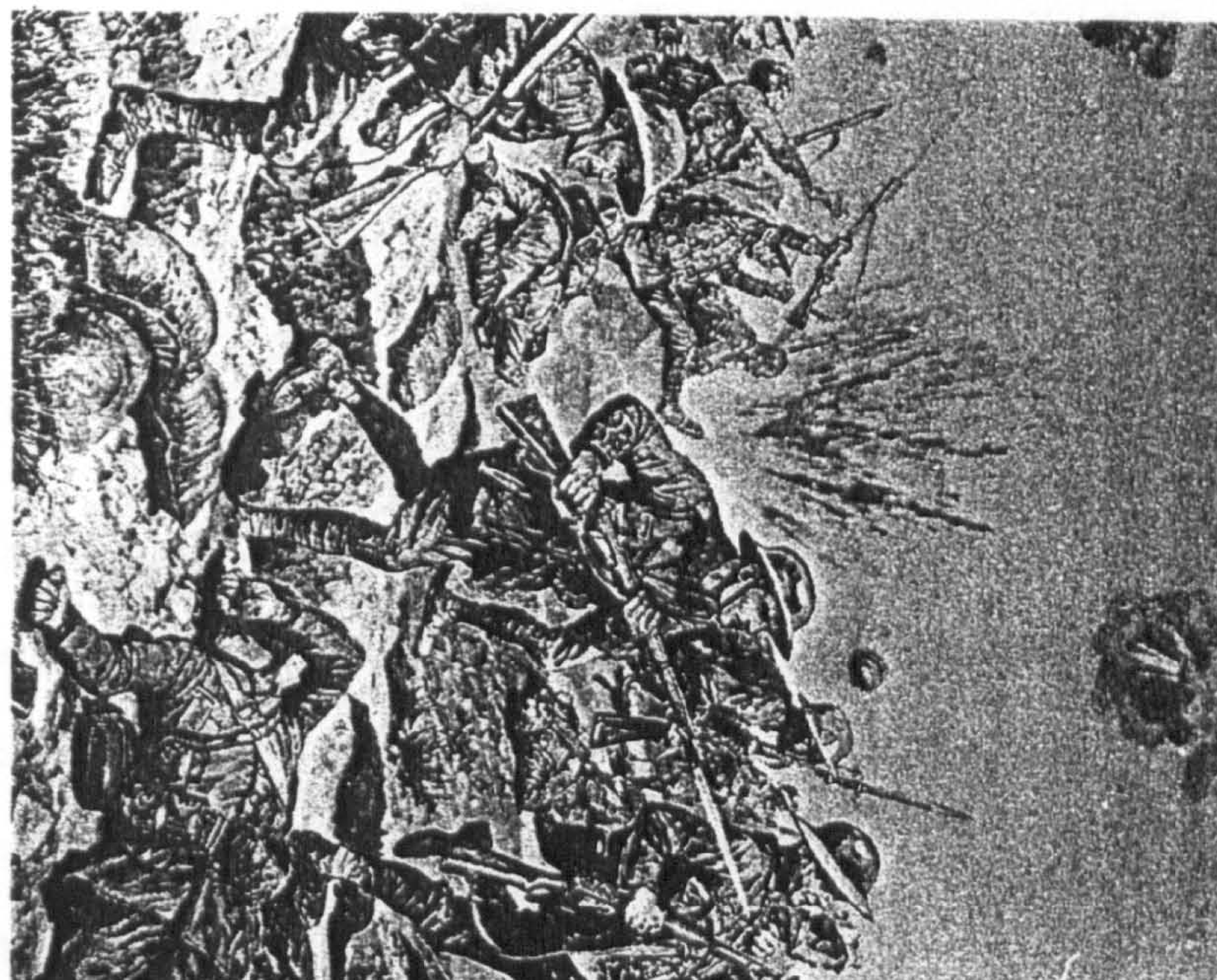
There were several memorable episodes where the aggressive demands of football and warfare seemed to merge. The London Irish, who led the territorial division at Loos, were watched with astonishment as a football was dribbled over 1,400 yds and eventually kicked it into the German trenches, crying "goal!". Not surprisingly, at the Front they were known as "The Lucky Irish".

The most famous example of "playing the game" took place on 1 July 1916, the first day of the Somme. The first sign of the British advance against the German Front Line, before Montaubon was a football sailing through the air, kicked by Captain W P Nevill of the 8th East Surreys. The objective was to encourage the men, and according to the only surviving officer, Second Lieutenant C W Alcock, there were two balls, on which the following was printed:

> "The Great European Cup-Tie Finals. East Surrey v Barbarians.
>
> Kick Off at Zero"

On the other, in large letters was this: "NO REFEREE". A prize was offered for the first platoon to dribble to the German trenches. Despite tremendous losses, the press covered the story sensationally. "Glorious East Surreys. A Football Match with Death in Picardy", The Evening News announced on 11 July, and the Daily Mail published the following poem. (Parker, 1987).

> On through the hail of slaughter
>
> Will gallant comrades fall,
>
> Where blood is poured like water,



THE POLITICS OF SPORT

They drive the trickling ball.

The fear of death before them,

Is but an empty name;

True to the land that bore them,

THE SURREY'S PLAYED THE GAME.

Prevention

In contrast, on Christmas Day, 1914 on the Western Front football games arose spontaneously between British and German troops. (Canning, 1967). Convivial greetings were exchanged and rough-and-ready games took place in no-man's land between the trenches. Those at home suggested that this episode represented more than a seasonal desire for peace. Essentially through football antagonists were rendered more conscious of their similarities and less aware of their differences. Differences promote war; the perception of similarities weakens it. (Ashworth, 1980). This would explain reports that Company commanders responded with disciplinary severity afterwards.

This historical review offers a clear insight into the frequently debated role of aggression in football. A common view is that soccer has some cathartic value; by engaging in aggressive sports we rid ourselves of 'pent up' aggressive emotions, but such an analysis is both unnecessary and misleading. These behaviours can be adequately explained in terms of their consequences when viewed in a historical perspective. Behavioural analysis directs our attention to the consequences of behaviour in the sport itself. (Dickinson, 1976).

It can be concluded that aggression in soccer can be manipulated by changing the contingencies of reinforcement; and only when these reinforcers have been identified can our behaviour be altered. This insight offers encouragement for those who feel that contact injuries are not an inherent part of the game and therefore such soccer injuries can be reduced without radically changing the games composition or potential appeal.

2.1.2. The History of Sports Medicine and its Application to Soccer.

Sports Medicine is a comprehensive term that includes the treatment and prevention of sports related injuries, with the prescription (and postscription) of certain sportive activities for individual athletes and physiological research intended to maximise athletic performance. In recent years there has been great progress in the scientific study of exercise and sport as stated by R Johnson, the Editor of Science and Medicine of Exercise and Sports, in 1960. He also explained that the entire field of Sports Medicine research remained diffuse and even bewildering.

The Greeks

In essence Sports Medicine has developed sporadically over a period of 2,500 years (Ryan A J, 1989). The Greeks, and in particular Hippocrates (460BC to 370BC) and Galan (200BC to 129BC) were doctors and teachers who appreciated a systematic approach to the body and upheld a close connection between exercise and medicine. Exercise was regarded as an essential part of health as part of the concept of hygiene. Specialists who developed a detailed knowledge of the body and its function were known as gymnastes. Although the potency of this association appeared to ebb with time, in the 19th Century the concept was resurrected and medical and physiological research was once again directed to improve our clinical and scientific understanding of Sports Medicine and the elite performer.

Hygiene

Plato, a contemporary of Hippocrates, is still remembered for the term "mens sana incorpere sano" which defines the Greek ideal of physical and mental health. In fact at this time physical activity was an integral part of education and both Plato's Academy and Aristotle's school were located in Gymnasia. The grand panathenaic festivals were athletic festivals held in Athens. The most important of which was

Olympia. Success in these events was rewarded with valuable prizes which allowed athletes to dedicate themselves to their sport. In essence this was the birth of the professional athlete (MacAulay, 1994).

Interestingly Galan wrote extensively about medicine and gymnastics including a significant work on health entitled De Sanitate Tuenda. He clearly recognised the considerable benefits of moderate exercise for both body and intellect. However, he cautioned against the excess of the professional athlete, "Athletes live a life quite contrary to the precepts of hygiene, and I regard their mode of living as a regime far more favourable to illness than to health." Hippocrates had been of a similar opinion which was in keeping with the concepts of hygiene that moderation in all things was an essential element of health and its preservation. Many of our modern conceptions, in fact still bear traces of the Greco-Roman origin. Although scientific attention was once again turned to understanding the exercising body in the late 19th Century, the ghosts of Hippocrates and Galan still linger in many popular ideas and practices. In the 1870s a few physiologists started to address questions relating to the exercising body and early experiments were focused upon the heart, circulation, metabolism and the maintenance of performance.

German Experience

It was Germany, with its international reputation in modern experimental science that became the first home of Sports Medicine as a clearly defined field of study.

As high performance medicine has evolved, and its power of observations have greatly increased, it has become more prescriptive and ambitious with respect to restoring the injured body and to increasing the level of performance.

This trend is evident in F Heiss's brief stages in the history of German Sports Medicine:

(a) the application of general medical knowledge to the athlete (1912 - 1925);

(b) the acquisition of a systemic understanding of the effects of sport on the human body (circa 1925-1955)

(c) and finally the development of Sports Medicine into a component of most medical disciplines from 1965 to date.

The American Team Surgeon

Germany pioneered the speciality of Sports Medicine as early as the 1890s and 1900s; although many athletic teams in the United States already had a team surgeon. However Sports Medicine did not formally achieve recognition, as a recognised speciality in the U.S.A., until the American College of Sports Medicine was formed in 1954. The earliest contribution of the medical profession to Harvard Athletics, was an attempt to minimise injury and maximise performance. Dr William Connont, who was appointed in 1879 as the first Team Physician, developed a treatment area which allowed Harvard Footballers to receive attention at half-time and encouraged local treatment and massage to enable players to return to the field refreshed. Prior to this development, players simply sat through half-time covered with a blanket. Remarkably, the treatment area was called Hampden, which coincidentally is the name of the Scottish National Football Stadium. (MacKay, 1995).

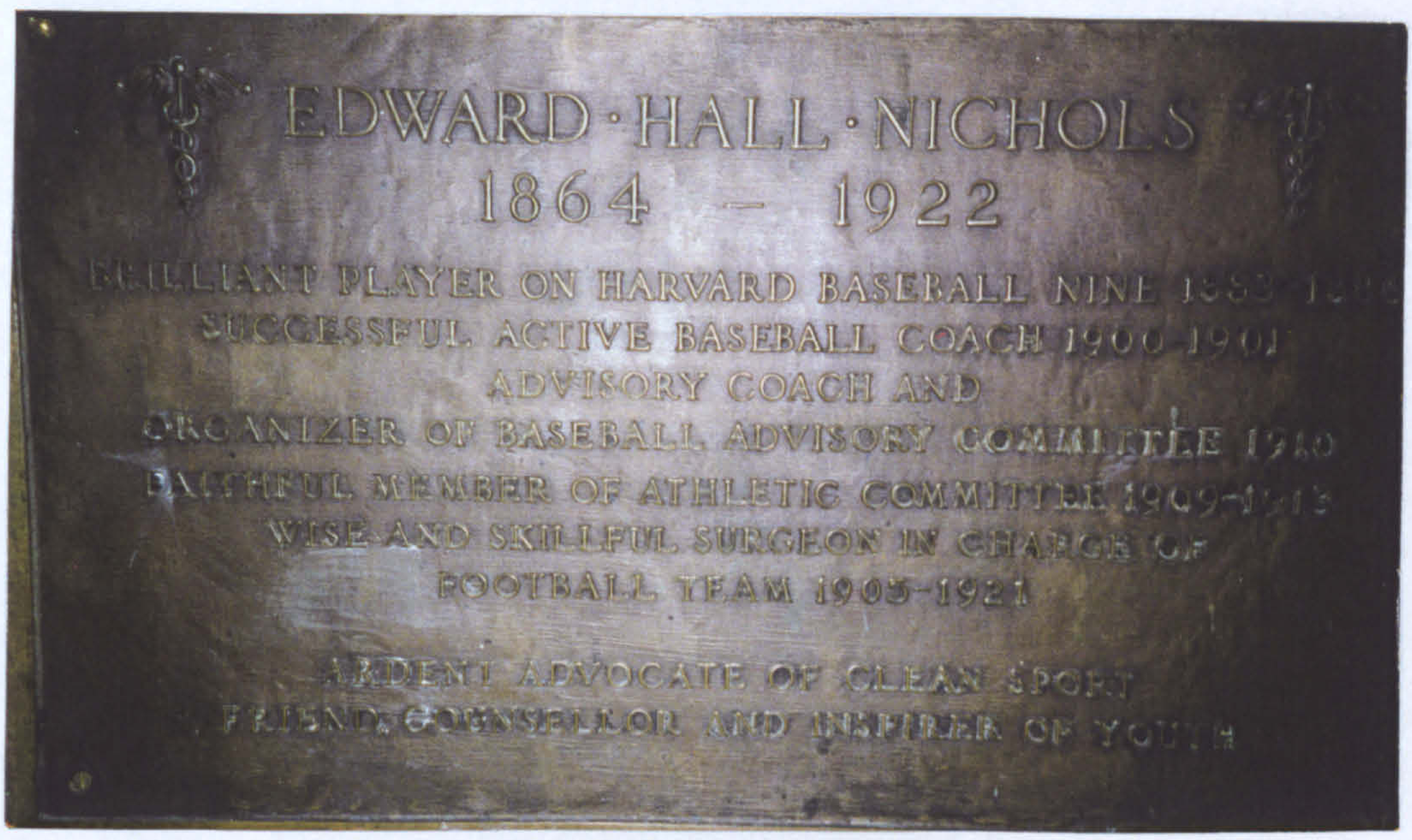
Dr Edward Hall Nicols, who was appointed as Team Surgeon in 1904, proved to be equally innovative and compiled the first record of sports injuries in consecutive seasons for American University Football; this data covered a period of five years up to 1909. He subsequently applied this pioneering work to great effect, by providing scientific evidence to prove that new football rules had greatly reduced the number of injuries per man. (MacKay, 1995). Essentially he carried out a very similar study to my own but almost ninety years ago. As a tribute to Dr Nicols' vision I visited Professor Lye Micheli, a former President of the American College of Sports Medicine, at the Boston Children's Hospital, and then set out with a personal mission to visit Hampden. Harvard's Cambridge campus is impressive. I sought directions and headed for Soldiersfield, the University playing field. It is an impressive stadium modelled on a Coliseum. There I met some interested coaches, who appeared to be infected with my enthusiasm and after referring to the original Harvard Year Books, offered directions. In my search I found that Harvard's Hampden, like Glasgow's, had been redeveloped, and a modern area now replaces it (see illustration).

A plaque, (see illustration) commemorates Dr Nicols' vision and his basic principles are still applied. He is remembered as "an ardent advocate of clean sport and a friend, councillor and inspirer of youth".

Scepticism

Since the introduction of Sports Medicine the goals of the sports physician have been subject to challenge. In 1867 the London Times reported the contention of a surgeon F C Skey "that even if they were not immediately apparent, calamities with overexertion in athletic sports were likely to appear in later life." This reference was cited by John Edward Morgan (1873) in the course of a critical enquiry into the after health of men who rowed in the Oxford and Cambridge boat race in the years 1829-1869, based on the personal experiences of rowers themselves, This concern about athleticism was extended into Public Schools and Universities and the Clinical Society took up the discussion, looking into reports of "severe injury to the heart from overstrain" and "hypertrophy among professional pedestrians." Inevitably the attempts to understand the body and improve optimal levels of

The Author Visiting the Redeveloped "Hampden" (Harvard Campus - Boston)



Plaque in Memory of Edward Hall Nicols

In Memory of Edward Hall Nicols: A Pioneer of Sports Injury Prevention physical activity gave rise to fanciful theorising and the persistence of "pseudo-science" (Berryman *et al*, 1992)

The Harvard Graduates magazine published Carol William Elliott's 1892-1893 Annual Harvard President's Report. It emphasised the importance of American intercollegiate athletics to the physical health and moral development of young men, however, he cautioned that the inordinate desire to win and the attendants evils of commercialism, course publicity, and hysterical excitement could ultimately result in a blight in all the Colleges. He concluded, that the intensity of excitement drained the "nervous energy of athletes and the brutality of contests blunted the sensibilities of players and spectators alike". (This reference was made in particular to American Football). Several years after this in 1905, a variety of undisciplined transgressions in a Harvard Yale game, prompted an enquiry from President Theodore Roosevelt.

Victorian Athlete

Victorious athletes of the ancient panhellenic festivals, were accorded the status of "heroes" - superior to other men; inferior to gods. In Britain the Victorian athlete embodied the strength, fortitude, tenacity, courage and something tantamount to moral rectitude. In summary, the athlete was repeatedly said to possess qualities that were needed to extend and protect an empire. The athlete represented the future of the "race". (Girouard, 1981). This theme was evident in Joseph Strutt's monumental "Sports and pastimes of the people of England," asserting that the traditional recreations and sports had been instrumental in making Britain great (Hone, 1831).

Football

In 1858, The Edinburgh Review found that football matches in Tom Brown's Schooldays were described in the style of a Homeric battle, with a certain combination of zest and solemnity. It continued, for which the only appropriate word was "agon" - "something between a battle and a sacrifice". James Mannigan appropriately concluded that "success and ruthlessness tempered by a certain amount of courtesy and ethos which held that victory must be attained within the rules". Essentially he was describing a rising class of gentlemen amateur.

As Scottish football gradually evolved, the character of the sport and participants changed as did the input of the sports physician. The initial affection of the Scots for association football was immediate and permanent. Unlike the English game, which had its origins within the Public School system, football in Scotland provided an enjoyable pastime but could well provide the escape route from the drudgery of heavy industry for those fortunate enough to be gifted footballers. (Crampsey, 1990).

The Professional Player

At the inception of the Scottish League amateurism was the norm, however as early as September 1890 a club named the Adventurers protested against St Bernards after they had lost a cup tie. They protested on the grounds that the Edinburgh side were professional, having lured a professional player Ross to Edinburgh from Dunfermline Athletic and paid him a weekly wage for playing football, although there was also the bait of a job in a Biscuit Factory. This job would have paid him less than he had earned in Dunfermline but there would be an additional payment of 10 shillings per match. Although, the drive to win and succeed at all costs did evolve gradually within the Scottish game, there was a surprising reluctance to accept what was potentially on offer from the pooled wisdom of medical science, Sports Medicine, and related research. In an ironic way, this may well be reflected in the relatively low levels of performance enhancing drug which have been detected within Scottish Football. The club trainers, who were often retired players, were traditionally responsible for the training and preparation of players and their well-being.

Physical Education

This traditional tendency therefore was based broadly on the concepts of physical education of that time and the, "pseudoscience which surrounded it". For example the playing staff of Aberdeen Football Club on October 12, 1938 were issued with the Pittodry code of honour by the then Manager, David Halliday. This stated:

1. Players will see that they report each morning at 10 am for training
2. There must be no dancing after Tuesday
3. There must be no smoking within 3 hours of any match
4. There must be no smoking during the train trips south to any match
5. Any tendency to "blind eye the instructions of Captain or Trainer will be a breach of contract to be considered in session by the Aberdeen Club."

There is little written about the association of Medical Practitioners with Scottish Football clubs and often the association was based on geography or the support and enthusiasm of local Practitioners. Mr Bob Crampsey, a respected historian of the Scottish game pointed out (by personal communication) that some kind of medical provision would have had to be provided after the National Insurance Act of 1908 or thereabouts. The first recorded case of medical provision, provided by a Club, was that of St Mirren in the 1920s who paid the Nursing Home expenses for a player who was suffering from acute depression. However until the 1960s immediate medical treatment tended to be in the hands of basically unskilled trainers who were almost always former players. Interestingly, Bill Struth a famous Rangers Manager, got his first connection with football as a Trainer with

Clyde prior to which he had been a professional runner. The current position demands that a Doctor is present and in certain situations a crowd Doctor is also required and increasingly Physiotherapists are required to be Chartered.

Modern Sports Medicine

Within the last five years interest in Sports Medicine and Science in Scottish Football has increased exponentially. This is evident by the support of the Club Doctors and Physiotherapists of the Scottish Football Association for the purpose of this study. Increasingly clubs are appreciating that team stability and subsequent success is dependent upon optimal performance and avoidance of injury.

2.2 Physiological Demands of the British Game

2.2.1. Motion Characteristics

The application of time and motion analysis to football provide a means of objectively assessing the individual demand placed upon players participating in soccer. This is possible using video analysis or real time analysis during play. This has now been superseded by computers programmed with their own notation systems for data analysis.

Understandably physiologists are more interested in motion analysis as it relates to the individual participants and their work profiles. The overall physiological assessment can balance both the activity off the ball and when in possession, as well as the average work to rest ratio. Allowance is made for the varying levels of competition and player position. The overall objective of such analysis is to provide an insight into the demands of a competitive match so that training can be appropriately planned to optimise performance and prevent injury (Reilly and Thomas 1976).

Distance

Published data for the distance covered by players during matches varies significantly. In 1974 (Knowles and Brooke, 1974) the mean value for the full distance covered during games was 4,834 metres. This was using a form of hand notation for assessment and varies dramatically with a Russian study (Vinnai, 1973) which reported Russian players covering a distance of approximately 17 kilometres. Although the methodologies involved in these assessments may contribute to the variance, several other important studies are regarded as being reliable. Reilly and Thomas (1976) studying English League players and Bangsbo *et al* (1991/92) from studies of Danish League football, both reported results which were objective and valid.

Van Gool (1987) successfully studied University players using a camera mounted at a height of approximately 57 metres, then using a process of computer analysis they could assess not only the distance covered but the velocities and accelerations. It concluded that during the match players covered 10,225 metres (± SD = 580 metres). Of this 42.9% was described as low intensity and 42.6% was of medium intensity and 7.5% high intensity.

Work Rates

Overall analysis suggests that work rate during play demands that a footballer should be able to run 9 to 12 kilometres, more or less continuously. They should also have the physiological capabilities for high level intermittent exercise, with a ratio of low intensity to high intensity of approximately 2.2 to 1 by distance (Reilly and Thomas, 1976). This study was performed on English professional soccer players; however, in terms of time, this ratio is about 7:1 (Mayhew and Wenger, 1985). Interestingly, less than 2% of the total distance covered in a game involves the player holding possession of the ball. Each game calls for 1,000 to 2,000 discrete bouts of action which incorporate rapid changes of direction, acceleration and deceleration, as well as vertical lift (Reilly and Thomas, 1976, Bangsbo *et al* 1991). At the highest levels of competition in the English Premier Division, players change activity every five or six seconds and average short rest periods of approximately three seconds every two minutes. Sprints appear to be relatively short averaging 15 metres once every 90 seconds (Reilly and Thomas, 1976). Observations between 1970 and 1990 confirm similar profiles of activity at the highest professional level, although there appear to be tactical and philosophical changes in the pattern of play. Reilly and Thomas remain the leading authorities on motion characteristics in professional soccer in Britain and have reported that outfield players during a match spend 25% of the game walking, 37% jogging, 20% cruising submaximally, 11% sprinting and 7% moving backwards. It is noted that these categories are to some extent artificial and represent a broad continuum of player motion.

Skills

The element of skill involved the playing activity also contributes to the work rate, the most demanding being passing and controlling a ball, although heading, tackling, and dribbling also play a lesser role. (Reilly and Holmes, 1983).

Teamwork

General aspects in relation to the team affect work rate and motion characteristics. For example, 5% more distance is covered in the first half as opposed to the second half in Danish league matches, as reported by Bangsbo *et al*, 1991 and other authors. Reilly in 1990, stated that the energy expenditure of an average outfield player was equivalent to a 75% VO2 max, or the level of energy expected of a marathon runner. Smaros in 1980, confirmed a strong correlation ($R = 0.89$; $N = 8$) between V_{O2} max and distance covered in a given match. This is in keeping with the findings of Bangsbo and Lindquist (1992), who were not only able to relate V_{O2} max to the distance covered in a given match, but also to a field test which now provides a means of independent assessment.

Playing Styles

Styles of play obviously have an impact upon work-rate. A direct system encourages rapid end to end play, which demands a high work-rate from all the team members. However, ball possession and particular dribbling, can increase the energy cost of running significantly, as a result of a shortening stride pattern. This additional cost of dribbling was a constant 5.2 kilojoules per minute, (Reilly and Ball, 1984) for players tested on a treadmill at various speeds 9, 10.5, 12 and 13.5 kilometres per hour for a five minute period. Cavanagh and Williams in 1982 confirmed additional energy cost by analysing oxygen consumption during dribbling activities. Other activities such as running backwards and sideways increased energy cost to the individual player (Reilly and Bowen, 1984), but with practise, the efficiency of these movements could be improved.

Player Position

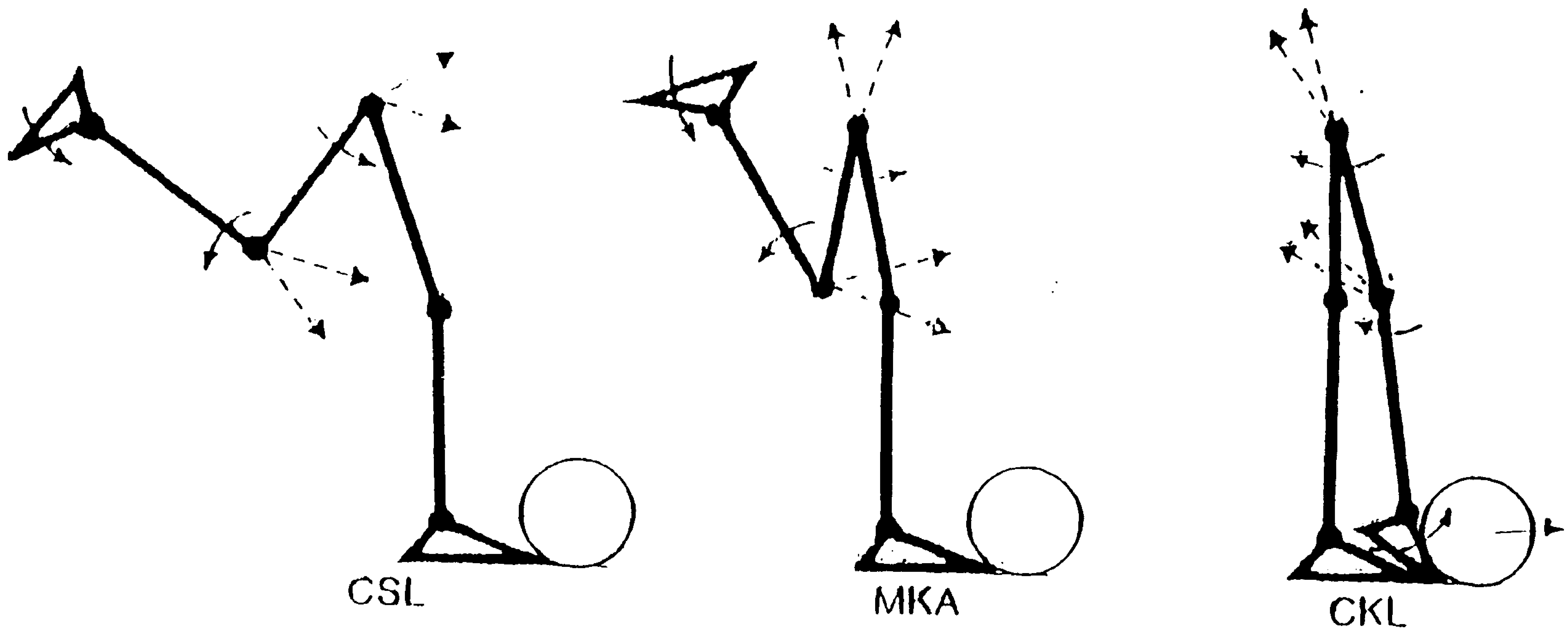
Workrates are clearly affected by position, for example midfield players cover the greatest distance, with central defenders covering the least. Reilly and Thomas (1976) noted that full backs sprinted less frequently than centre backs, but this situation may have been reversed because of tactical changes within the game. Ekblom (1986) assessed Swedish professional players and found that midfield players covered an average distance of 10.6 kilometres, forward 10.2 kilometres and defenders 9.6 kilometres in any given match. However the greater distance covered by the midfield players tended to be at a lower speed, well within their aerobic capacity (Bangsbo *et al*, 1991). The number of jumps to head a ball also varies according to position, the highest frequency was 13.4 ± 6.8 for central defenders, reported by Withers *et al* (1982) with only 5.2 ± 3.1 for midfield players. Interestingly, goalkeepers although relatively sedentary, require to perform intermittent explosive tasks and cover approximately 4 kilometres per game, which should be reflected in their training practices.

2.2.2. Biomechanics

Kicking

Kicking involves a complicated and co-ordinated sequence of body movements. The resultant forces and moments of kicking are illustrated diagramatically (Luthanen, 1988).

Robertson and Metcalf (1968) recorded foot velocities of 18 to 24 metres per second prior to contact, although this result has varied slightly between authors.



The range of directions of the resultant forces and moments of kicking are illustrated in selected phases. CSL, the phase when the first contact of the support leg occurred; MKA, the phase when the knee angle was in its minimum; CKL, the phase when the contact of kicking with foot and ball occurred (Luhtanen 1988a).

The key components of kicking are; the strength of hip flexion, the velocity and torque of the knee and the relative stability of the ankle. In the knee, the velocity reaches a peak after the hip's peak velocity has been reached; the thigh is almost stationary at impact, while the leg and foot have reached peak velocity and by implication zero acceleration. (Huang *et al,* 1982). Obviously, joint mobility is an essential component of a controlled kick and it has been found that skilled players have a greater capacity to relax their antagonist muscles during the swing phase of kicking, which may represent a training phenomenon. (Bollens *et al,* 1987). It is worth noting at this point that the forces involved with kicking a ball are considerable and this has to be considered in particular with relation to younger players with immature skeletons.

Heading

The mechanics of soccer heading involves striking the ball with a forehead; the arms are then thrown back, the head is tucked to the chin and body segments, the trunk and hip flexors are activated and at time of contact, the head and neck function is one unit. The timing of contact and associated jump is obviously a skill which requires extensive practice to ensure body segment co-ordination. The biomechanics of the impact relate to ball mass and velocity, as well as the impact time, which ranges between 13 and 20 milliseconds. The mechanics of heading have been studied in depth by Lynch (1994) who concluded from video analysis that heading resulted in an average impact of between 200 and 300 Newtons while direct measures using a pressure sensor gave a peak of 400 to 500 N.

The concerns surrounding repetitive heading in soccer goes hand in hand with those relating to repetitive trauma in other sports, in particular boxing. Dementia resulting from chronic brain damage, although a defined problem involving 9 to 15% of former professional boxers, is an extremely rare occurrence in professional football. Concerns relate more directly to repetitive contact especially in juveniles with immature neck muscles; however any subtle impairment can be difficult to assess and neuropsychometric testing remains the gold standard. In 1983 EEGs were performed on 10 German soccer players and only one had a degree of focal slowing. The study was then extended in 1989 to involve 69 active Norwegian players but no correlation was found with the number of years of heading. In contrast to this in 1991 Tysvaer *et al* reawakened concerns of soccer injury to the brain reporting a degree of intellectual impairment in 80% of former Norwegian football players. The most comprehensive study to date was performed by Hagland and Eriksson (1993), who compared groups of Swedish boxers, former and active soccer players, and track athletes, but found no significant difference on CT scan, MRI scan, EEGs and psychometric testing.

2.2.3. Player Profile

Basic Physiology

Saltin's (1973) work on glycogen depletion proved a great stimulus for further research into the physiology of soccer. Muckle (1973) reported improved team performance in soccer when players supplemented their diets with glucose syrup.

Cardiovascular Fitness

Soccer has previously been defined as an essentially aerobic activity associated with intermittent explosive episodes of anaerobic activity. Blood lactate concentrations have ranged from 4 up to 11 moles during and after a game, although this depends upon the activity just undertaken The cardiovascular fitness of soccer players is therefore an essential aspect of any structured training programme. Heart rate during exercise has been used as an indirect measure of VO_2, however this tends to overestimate the VO_2 as it does not make allowances for additional unpredictable activities associated with soccer such as acceleration, deceleration, change of direction and jumping.. Van Gool (1987), observed the mean heart rate for central defenders was approximately 155 while for a midfield player 170 was average. This is in keeping with research by Ekblom which confirmed that the average heart rate during match play is 80 to 90% or 10 to 15 beats per minute lower than individuals maximum heart rate. This can be associated with increased core temperatures often higher than 39^{o}C and with high levels of perceived exertion from the players themselves. This activity would be in keeping with an estimated aerobic level of activity of approximately 75 to 80% of maximal. Elite players were noted by Bangsbo *et al* in 1991 to undertake approximately 7 minutes of high intensity exercise during each match. It is also of interest that intermittent exercise which characterises football gives rise to a greater increase in body temperature than continuous exercise.

Anthropometry

The physiological profile of individual players represents the heterogeneity of individuals involved, however in general the physiological profile will reflect the training regimes and type of competition as well as the stage of the season. One of the more extensively studied aspects of the British game has been that of basic height and weight assessment with studies by Reilly (1979) of the English League and subsequently by White *et al* (1988). In White's study the average height was 180.4 ± 1.7 cm and the body mass averaged 76.7 ± 1.5 kg. The value of these assessments appears to be limited when considering the overall racial variation of players today and the differing levels of skill. Although players traditionally tended to carry a little more than their ideal weight when compared with other athletes the pattern appears to be changing. The one record of a Scottish club was that of Aberdeen FC in 1974 with an average percentage of body fat of 14.9% which was considered high. However in White's study in 1988 for a top English team a preseason body fat percentage of 19.3% was recorded. This is assumed to reflect the relative inactivity and excessive food intake of the closed season combined with the inability of the players to discipline themselves.

Age

Age remains an issue although the consensus opinion is that physiological fitness should be maintained without difficulty into a players third decade before signs of deterioration appear. Deterioration has a more pronounced effect on anaerobic activities and fast twitch fibres, although aerobic activities may well be preserved or even improved. There is a tendency with age to carry an increasing amount of weight and in footballing terms any additional fat can be regarded as an unproductive dead-weight. A player who increased his level of activity and training input may well increase his weight, although when assessed physiologically his percentage of body fat may well have been reduced and subsequently replaced by muscle.

The respiratory quotient during a match is averaged at 0.88 which would translate into a ratio of 60% carbohydrate and 40% fat.

Muscle

Muscle physiology has been extensively studied and, as laboratory studies develop, our appreciation of injury prevention and our understanding of rehabilitation continues to extend. Experimental studies have confirmed that muscle strains most often occur during eccentric activation. The location of injury is primarily adjacent to the musculotendinous junction and the viscoelastic characteristics of muscle clearly demonstrate that fatigued muscles can absorb less energy prior to failing than a glycogen replenished muscle. Heat has an inherent effect on the viscoelastic properties of connective tissues within muscle and cooler temperatures, therefore predispose muscle to injury and diminish performance (Astrand and Rohdall, 1977). Injuries are more likely if warm-up is incomplete or inappropriate (Reilly and Stirling, 1993). The soccer player is associated with decreased muscle flexibility, in particular affecting the hamstring and hip adductor muscle group (Ekstrand, 1982). Although the natural history favours recovery, recurrence is frequent and treatment has to be orientated as much towards prevention as to recovery (Garrett, 1990).

Muscular strength

Strength training improves both muscular strength and kick performance (Proft *et al*, 1988). The balance however between quadriceps and hamstring strength has been much debated, in particular whether imbalance predisposes to injury in football (Fowler and Reilly, 1993). The most important use for this ratio is that if a pre-injury level can be re-established, then it can be used as an endpoint for rehabilitation. It is interesting to note that Pele showed significant hamstring to quadriceps imbalance as well as a clear limb preference, with his right leg being significantly more developed than his left.

Muscle fibre types have been studied in detail by Bangsbo and Mizuno (1988). The gastrocnemius in Danish professional soccer players after three weeks of inactivity resulted in a preferential decrease in the diameter of type 2A fibres, although the decrease was small affecting approximately 7% of the cross sectional area. The oxidative capacity of the muscle decreased rapidly due to a decreased capillary blood supply and mitochondrial activity, although the size of the slow twitch fibres remained unchanged.. The various muscle fibre studies performed seemed to agree that about 60% of fast twitch fibres predominate in the quadriceps of soccer players. This sport specific characteristic may well relate to the mechanics of kicking.

2.3. Physical Conditioning and Assessment of Performance

2.3.1. Aerobic

The general health benefits of aerobic exercise are now clearly established (Peterson and Renstrom, 1985) and the recognised benefits include improved cardiovascular fitness, appropriate weight control and glucose tolerance, as well as psychological benefits and a possible effect on the ageing process.

The benefit of aerobic activity however is enjoyed at a cost. The epidemiology of soccer injuries illustrates this and explains why a greater understanding of the aetiology of soccer injury is required, through valid analysis, to prevent further injury. (See Introduction). It is recognised that individuals whose general fitness is below normal for a specified group are more prone to injury from overuse as well as acute trauma. (Peterson and Renstrom, 1985).

Aerobic Assessment

It is therefore essential to estimate an individual player's basic cardiovascular status and establish practical reliable sports specific tests to monitor his fitness. Such tests offer the opportunity to set achievable goals for the individual player and also provides a reliable standard for assessment at the beginning of preseason training or after a period of rehabilitation. Various practical considerations have to be remembered in observing such tests, such as the learning component which allows players to improve at a specific test purely through repetition, rather than improved fitness. Players should also be in a standard condition before performing these tests which ideally should be performed at the same time in the day with the player rested adequately for the 24 hours before assessment.

Laboratory Studies

The standard laboratory assessment of aerobic capacity and anaerobic threshold would normally be performed in the laboratory on a treadmill with incremental running to exhaustion. Heart rate, ventilation, oxygen consumption and blood lactate production would be measured and aerobic and anaerobic thresholds defined. In the playing situation heart rate can be taken as a rough estimate of the level of exertion, whether above or below the anaerobic threshold. The multistage fitness test is a test designed to assess anaerobic threshold for an individual player and is structured to include 20 metre shuttle runs which are performed at progressively increasing speeds which are set by an audio-visual tape. As the speed of the tape increases in an incremental fashion, the point at which the player has to drop out can be taken as a reliable standard for comparative scoring. This basic test which is commonly used for professional footballers (see Appendix) has been modified by Bangsbo (1994) to include interval periods of rest which correspond more accurately with the game of soccer. Although perhaps more representative of soccer conditions, this test has not been accepted quite as readily as the multistage shuttle run (Brewer *et al*, 1988).

2.3.2. Anaerobic

Brewer and Davis (1992), assessed the physiology of professional footballers in England. The average sprint over a distance of 15 to 40 metres was the best sports specific assessment of anaerobic capacity. Sprinting obviously involves a variety of inputs which relates to motivation and skill as well as anaerobic power. Sprinting as a reference point for assessing their anaerobic function however, appears to have so many potential variables such as running surface and starting positions, that this test is rarely applied. Recognised tests for assessing anaerobic power currently used by the English FA include isokinetic leg power test which is performed to measure strength of both hamstrings and quadriceps on both legs. The players are expected to perform three maximal flexor and extensor tests through a range of 90° at a speed of 60° per second. A variable which must be considered in assessing the anaerobic power of a professional footballer is the difference in leg strength between the dominant and non-dominant leg. Goslin and Charteis (1979) suggested that leg strength differences should not exceed 10 to 15% and that peak hamstring to quadricep ratios should be within a range of 0.3 to 0.8, although angle specific torques have not been clearly assessed. This is relevant as professional players are capable of producing greater torque and speeds than amateur players.

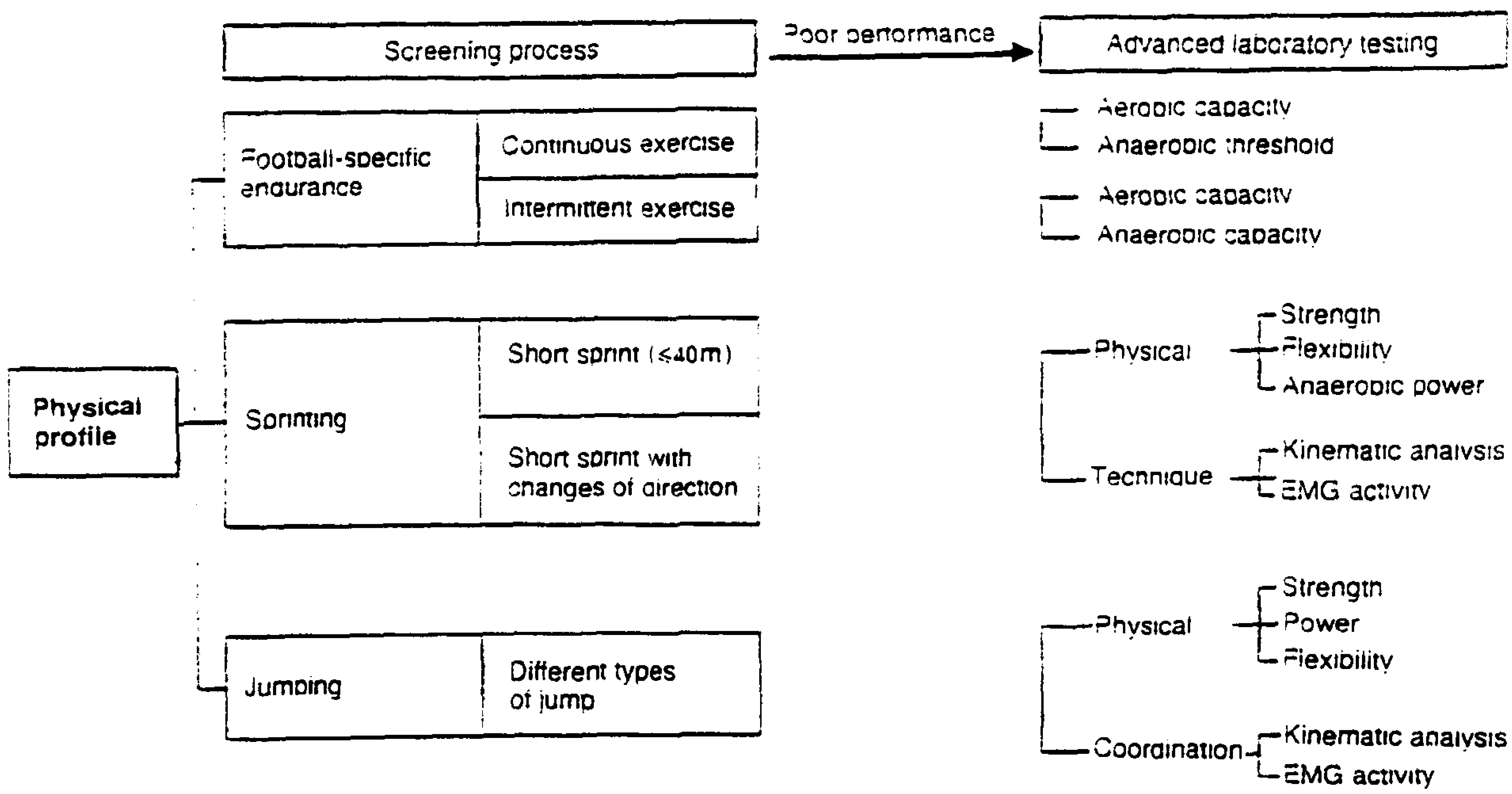
Sprinting can be assessed in a more controlled manner using a modified ~~windgate~~ Wingate test where the player performs 8 separate sprints each of 6 seconds duration, between which a 30 second recovery period is allowed. The computer is then able to assess the fatigue index which is a reliable indicator of the individuals ability to cope with intermittent anaerobic exercise and recover rapidly.

A practical and applied method of assessing professional footballers is detailed in the Appendix, however the illustration from the IOC Handbook on Football, provides an algorithm which is well thought through and practical. The more advanced laboratory testing, would however be restricted to professional athletes.

Heart Rate Monitoring

A functional assessment has been reported by Luhtanen (1994). In a laboratory aerobic and anaerobic thresholds were defined and these were programmed into a Polar Sports Tester for players. The players then used these testers for a 2½ month period involving both training sessions and matches. The heart rate was then transferred on to a PC and analysed using the Polar analysis software. This allowed an overall assessment to see whether the demands of training corresponded to those of the match situation. From this work it was estimated

A TESTING MODEL FOR FOOTBALL



that the maximum heart rate of a Finnish soccer player was over the anaerobic threshold for 14% of a match and under the aerobic threshold for 30% of a match approximately. This correlated well with the high intensity training sessions during which 21% of the session involved high intensity work above the anaerobic threshold where the average work rate was similar. Interestingly, when the training was directed specifically towards skills, the work rate was approximately 20% less than that recorded for matches. They concluded from this work that the training sessions as defined in Finland were adequate to maintain a VO_2 max at a constant for the whole of the season. During the period of study they reported a small incremental increase in the average anaerobic capacity.

APPENDIX

THE F.A. HUMAN PERFORMANCE DEPT.

ASSESSMENT OF GORDON McKAY

RANGERS F.C.

JANUARY 1989

INDIVIDUAL RESULTS: GORDON McKAY

1. SHUTTLE RUN TEST (ENDURANCE/STAMINA)

Gordon completed all of the shuttles on the 13th level, resulting in a maximum oxygen uptake value of 60.6 units of oxygen per minute. This value is the best indicator of a players endurance or stamina (*aerobic fitness*). This value is close to the average value for the Senior Squad, and comparable with the type of values found in professional footballers. It is, therefore, well above the type of value which would be expected in an 'average' 20-30 year old male. These results indicate that this aspect of Gordon's fitness is excellent.

2. SPRINT BIKE TEST.

This test is to measure the player's ability to recover from and then reproduce short, intensive bursts of exercise (*anaerobic exercise*). To assess this, the amount of fatigue from the start to the finish of the test is calculated and expressed as a percentage decrease in performance, or 'fatigue index'. The **lower** this value, the better. Gordon's value was **7.1%**, compared to the squad average of **11.6%**. Therefore Gordon's fitness in this area is good, and again comparable to that found amongst the players. The combined results of this test and the shuttle run test illustrate that Gordon has an excellent standard of aerobic and anaerobic fitness.

3. LEG POWER TEST - HAMSTRINGS AND QUADRICEPS.

Each player performed two tests on each leg to assess power and muscular endurance of the hamstrings and quadriceps. Gordon's current results indicate that the power and endurance of his right hamstrings is poor, and he therefore requires a **4-6** week period of low weight hig repetition exercises to improve this. This should be undertaken at least **twice** a week.

4. BODY FAT PERCENTAGE

This test was to calculate the percentage of Gordon's total weight which consists of fat. Ideally, for a male of his age, this value should be approximately **15%**. Values substantially in excess of 15% indicate that weight needs to be lost. Gordon's body fat percentage was found to be **9.1%**. This result indicates that Gordon has no current weight problem since he is not carrying large amounts of excess fat, and that his current weight of 11 stones 11 pounds (75 kg) is fine.

5. HAEMOGLOBIN

Haemoglobin is the 'oxygen carrying' component of the blood, and for its formation is dependant on sufficient iron in the diet. Values of around 130 grammes of haemoglobin per litre of blood, or below, indicate that there may be a need to increase dietary iron intake. Generally for adult males, values range between **130** and **180** grammes per litre. Gordon's current value was found to be 157 grammes per litre, which is a normal value and within the acceptable range, showing that his dietary intake of iron is currently adequate.

SUMMARY.

Gordon's results indicate that he has an excellent 'all-round' standard of aerobic and anaerobic fitness for someone of his age which is comparable with that of fully fit professional footballers.

Gordon's quadriceps were found to be normal in terms of their local muscular endurance and power, but his hamstrings were found to be lacking in these areas. He should therefore concentrate on low weight high repetition exercises to develop this muscle group.

His body fat percentage and weight are fine, whilst his haemoglobin concentration is currently normal.

2.3.3. Nutrition

Professor Clyde Williams (1994), a respected world authority on nutrition concluded his chapter on diet and sports performance in the Oxford textbook of Sports Medicine stating "the clear message from over a half century of research into the links between food, nutrition, and exercise capacity is that, next to natural talent and appropriate training, a high carbohydrate diet and adequate fluid intake to avoid dehydration are the two most important elements in the formula for successful participation in sport". He qualified this statement by putting it in the context of a well balanced diet sufficient to meet the athlete's needs.

Carbohydrate

Carbohydrate is an essential energy source for any player training intensively and glycogen is stored in liver and muscle. It was found that glycogen is essential if performance was to be maintained throughout the 90 minutes of a game and Saltin (1973) confirmed that 25% less distance was covered by those who were glycogen depleted. In terms of running speed, players with low glycogen covered approximately 50% of the distance walking and 15% at low speed compared to the control group who walked for 27% of the match and were able to maintain high intensity effort for 24% of the game. Muckle (1973) studied the relationship between diet and the goal scoring ability of a professional soccer team following for a full season. For the first 20 matches the players were given additional carbohydrate in the form of glucose syrup during the day prior to competition and 30 minutes before play. In the second half of the season no supplement was provided. He concluded that the number of goals scored in the second half of each game increased when the carbohydrate supplement was provided and there was a reduction in the number of goals conceded. Kirkindall (1988) qualified this study and demonstrated that players who consumed a drink composed of 15.5%

carbohydrate during a game and at the interval were able to cover more distance in the second half.

As well as carbohydrate, fat oxidation represents approximately 40% of the respiratory quotient of an average footballer. Free fatty acids are drawn from intramuscular stores or fatty tissue, and interestingly the glycerol produced from the lipolysis of the free fatty acids may be a significant source of glycogen during a match.

Hydration

It is recognised that the primary cause of fatigue is usually glycogen depletion for exercise lasting more than an hour such as soccer. Water balance is obviously an essential aspect of physiological homeostasis and cellular function and depletion can contribute to fatigue.

Dehydration may result in hyperthermia, poor thermal regulatory control and carbohydrate depletion. This occurs due to decreased blood flow to muscle for energy generation and to skin for cooling, which may compromise performance.

Dehydration also affects the central nervous system increasing fatigue and impairing coordination. These topics are dealt with briefly in the, "Zurich Consensus Statement for Foods and Nutrition for Soccer Performance", which has been included for information.

Evaporation may be the only means of heat loss in high ambient temperatures. A rise in body temperature of 2 to 3 degrees may occur during prolonged exercise but most of the excess heat generated must be dissipated. Evaporation of one litre from the skin will remove 580 Kcals of heat energy from the player. It is estimated that a marathon runner (70 Kg running at 2hrs 30min pace) may require a sweat rate of 2 litres per hour to achieve sufficient heat loss. The importance of this information lies in the fact that fluid loss can seriously compromise performance. Neilsen (1992) demonstrated that a fluid loss of 2.5% body weight resulted in a staggering 45% in the capacity to perform high intensity exercise. This sweat rate is also associated with not only water loss but also other solutes (organic and inorganic) and some of these are discussed in the section titled "supplements". It is important to appreciate that despite these solutes especially sodium and chloride sweat remains remains hypotonic. The concentration of potassium and magnesium is higher than plasma but this represents a tiny proportion of the body's stores.

Rehydration after exercise is important and discussed briefly in the "Zurich statement". An important additional feature of rehydration is that temperature is no longer regarded to be as significant as previously thought as warm drinks can be absorbed equally fast. For the footballer it is important to appreciate that rehydration can be delayed by water ingestion. The rapid dilutional effect on plasma results in an increased diuresis and diminished thirst (Nose 1988). Alcohol should also be discouraged as it is a diuretic and it impairs glycogen resynthesis.

Fat

It is recommended that a players diet should provide 30 percent or less of his daily energy requirements as fat and only 10 to 15 percent as protein however their contribution physiologically should not be overlooked.

Fat is an extremely efficient energy source and contributes 9 Kcals per gram compared to only 4 Kcals per gram for both carbohydrate and protein. Fat is also essential for the absorption of fat soluble vitamins A,D,E and K and essential amino acids. At a cellular level these factors have an important role in cell membrane function.

The difficulty with soccer players is limiting their dietary content of fat. This is especially important after injury, as the diminished level of energy expenditure will inevitably result in weight gain if his diet remains unchanged. "Food exchanges", are encouraged by dietitians in such circumstances and this is also a very useful method for weight reduction. It is generally accepted that weight loss should not exceed 1 Kg per week.

Protein

The role of protein in athlete's diets especially in the traditional form of steaks, eggs and milk, continues to feature prominently in nutritional mythology despite an extensive education program. This dietary preference persists because of the mistaken belief that additional protein is essential to gain strength. Proteins in the form of their constituent amino acids are building blocks for cellular repair and homeostasis. The recommended protein intake for an athlete is 1.2 to 1.7 g per Kg of body weight.

Proteins are composed of 20 amino acids and the role of supplementation to improve performance remains controversial. It is argued that that amino acid supplementation may reduce fatigue (Newsholme 1991). There is circumstantial evidence for an association with increased free tryptophan levels and central fatigue. In summary, tryptophan contributes to the synthesis of serotonin (5HT) which acts as a central depressor. Exercise increases free tryptophan levels because increased free fatty acids can displace bound tryptophan from albumen. Glycogenolysis also reduces the number of branched-chain amino acids which favours the transfer of tryptophan to the brain at the blood brain barrier.

Creatine

Creatine is a high energy substance found in meat and fish and is known to play an important role in energy production during short burst of intensive exercise. Training doesnot increase creatine phosphate levels in muscle however supplementation can (Harris 1992).

Muscular Endurance

Fatigue remains a topic of continued scientific debate and research and the cause of the problem for the footballer, as with any other athlete, appears to be multifactorial. Lactate is a major product of anaerobic metabolism and the associated acidosis was thought to relate closely to muscle fatigue. This association has been questioned as research has confirmed that, despite persistently high levels of lactate after exertion full muscular contraction can be regained after a relatively short 2 minute period of rest (Sahlin and Ren, 1989). The level of ATP has also been found to be relatively high when a muscle is fatigued, although significant potassium fluxes and its close association with muscle contraction remains an area requiring further study. There certainly appears to be a training effect on muscular fatigue and therefore diet is only one factor which will help to maintain performance and prevent fatigue.

Supplements

As concluded by Professor Clyde Williams and the "Zurich Consensus Statement" additional supplementation is unnecessary for a soccer player with a well balanced diet and an added carbohydrate intake. Vitamins should be provided from adequate fruit and vegetable intake. However, it is worth emphasising that vitamin C has an important role, not only for iron absorption and cell turnover, but also with the structure of connective tissue and bone. Minerals are also an essential component of the diet (McDonald et al, 1988). Two worth emphasising are magnesium, which not only contributes to enzyme function but also to the contractility of muscle, and selenium which is an anti-oxidant and protects cell membranes against the damage from free radicals. Interestingly several studies have confirmed deficiencies of minerals and trace elements in professional German footballers,. This has been explained by the fact that the German diet does not compensate for the high excretion of sweat and urine and may result in deficiency. It has been suggested that such deficiencies may well increase the risk of injury in particular muscle strain or rupture, and therefore supplementation is recommended by the German Football Association.

Zurich Concensus Statement (1994)

"Soccer is a world-wide game. Participants include young and old, male and female, amateur and professional, healthy and less healthy, who all play with the common purpose of doing well at the game which they hold in such high regard. It is recognised that different cultural and other factors may influence individual nutritional recommendations.

Soccer training and competition, results in an increased energy demand that must be accompanied by an increased energy intake to sustain performance and maintain ideal body weight. In elite players, the average work rate corresponds to about 70% of maximum oxygen uptake. This corresponds to an energy cost of about 1000 to 1500 kcal (4000-6000 kJ), for a 70 kg player. The anaerobic energy systems are also heavily taxed during periods of match play. Repeated bouts of high intensity exercise during competition and training will deplete the muscle and liver glycogen stores.

Carbohydrate depletion may contribute to fatigue and reduced capability for performance during a soccer match. Soccer players engaged in strenuous competition and training should be encouraged to consume a diet that is relatively high in carbohydrate (at least 55% of total energy). If energy intake is low, or if carbohydrate requirements are high (e.g. during periods of intensive training and competition), the dietary carbohydrate intake should be increased even further. In practice, soccer players often experience difficulty in achieving adequate dietary carbohydrate intakes. They should be encouraged to consume a variety of simple and complex carbohydrate foods, in liquid and solid form, during preparation for, and recovery from, training and competition.

The high rates of metabolic heat production, during soccer training and competition, will lead to significant sweat loss. Dehydration will impair exercise performance and may result in heat-related illness. Increasing fluid intake before and during the game

Zurich Concensus Statement (cont.)

will reduce the degree of dehydration and can also supply carbohydrate to supplement the body's limited carbohydrate stores. Furthermore, the inclusion of electrolytes, particularly sodium, and carbohydrate in beverages or solid food consumed after a soccer match or training, will promote recovery.

Soccer play makes high demands on both endurance and muscle power. The daily protein intake of soccer players should be about 1.4-1.7 $g.kg^{-1}$ (body mass). This recommendation is easily attained, without supplementation by most players who have free access to a wide variety of foods in sufficient quantity to cover their daily energy expenditure.

Female athletes sometimes restrict energy intake due to their desire to lose or maintain body weight. In extreme cases this motive can result in eating disorders, but there is not clear evidence to suggest that this problem is common among female soccer players.

Despite low energy intakes and thus low mineral intakes in several groups of female ball-game players, there is no evident performance benefits from micronutrient supplementation. Nevertheless, iron therapy might be beneficial for iron depleted individuals. In athletes with infrequent or irregular menstruation, supplementary calcium might help to preserve bone density.

The general dietary needs of child and adolescent player are similar to those of adults. However there is at least one, important difference. During dehydration, children's core temperature rises faster than that of adults, which call for stricter controls of fluid replenishment.

To maintain a consistent balance between energy and nutrient intake and requirements, players should receive dietary advice from a qualified nutrition professional to cover all phases of the year, not just the competitive season."

Zurich Concensus Statement (cont.)

It is worth emphasising that metabolism remains a complicated process influenced by hormonal balance. It has been noted by Kjaer (1988) that growth hormone, as well as cortisol, are elevated during a football match. Temperature can also affect metabolic rate, accelerating the rate of glycogen breakdown which can be further accelerated by pronounced dehydration (Mustapha and Mohammed 1979).

2.3.4. Psychology

The psychology of injury.

The fear of injury which is shared by all soccer players, reflect the inherent insecurity of football as a profession and the potential frailty of an athlete. The psychology of recovery during rehabilitation and the associated pain and frustration have been studied by several authors including Wiese (1987). In practical terms it has been well recognised by surgeons such as David Dandy (personal communication) who often has to speak to professional football players after a career ending knee injury. He describes the experience as akin to breaking the news of bereavement. He recommends that the emotional impact of hearing that a sporting career is over through injury, requires not only a tactful approach by the physician, but also the support of family and friends. Psychology is also important in motivating a player during recovery from an injury by setting achievable goals and dealing with individual hurdles as they arrive.

Prevention

There is very little literature clearly demonstrating an association between psychological state and injury, however, it would appear that the lack of psychological harmony through conflict, anxiety, depression, low self esteem and confidence, correlates with a higher level of injury compared to those who are more positive mentally strong and confident. (Sanderson, 1977, Valient, 1981). This would be in keeping with the behavioural analysis of aggression in sport (see Chapter I).

The multidimensional model of stress

The multidimensional model of stress in athletic injury is illustrated following page 39. Although there are a variety of inputs in the model described by Anderson and Williams (1988), the most important aspect from the Sports Physicians perspective is that of the interventions. Interventions in essence involve positive goal setting and their effective use (Weinberg *et al*, 1990).

The German Experience

Liesen and Hollmann (1981) stated that stable top level performance was only possible with a combination of stable, psychological, neurological, endocrinological and immunological states of health; certainly a concept which has been embraced by the very successful German national side over the years. The neuroimmunology of exercise is still in its infancy, however, and this should be considered when attempting to optimise recovery from intense exercise. The stress of heavy training has been shown to affect players immunology, in particular T cell substrates and cytokines. Various stress management skills and relaxation techniques have been suggested as a way of attempting to modulate personal immunity and vulnerability to injury. (Lloyd, 1987).

Mental training

Sports psychologists have now introduced mental training as an essential component of preparation for a league performance. Ultimately the aim of this mental preparation is to reproduce a situation where the body is focused upon a task often resulting in a feeling of mild euphoria, free of fatigue and fear and full of confidence.

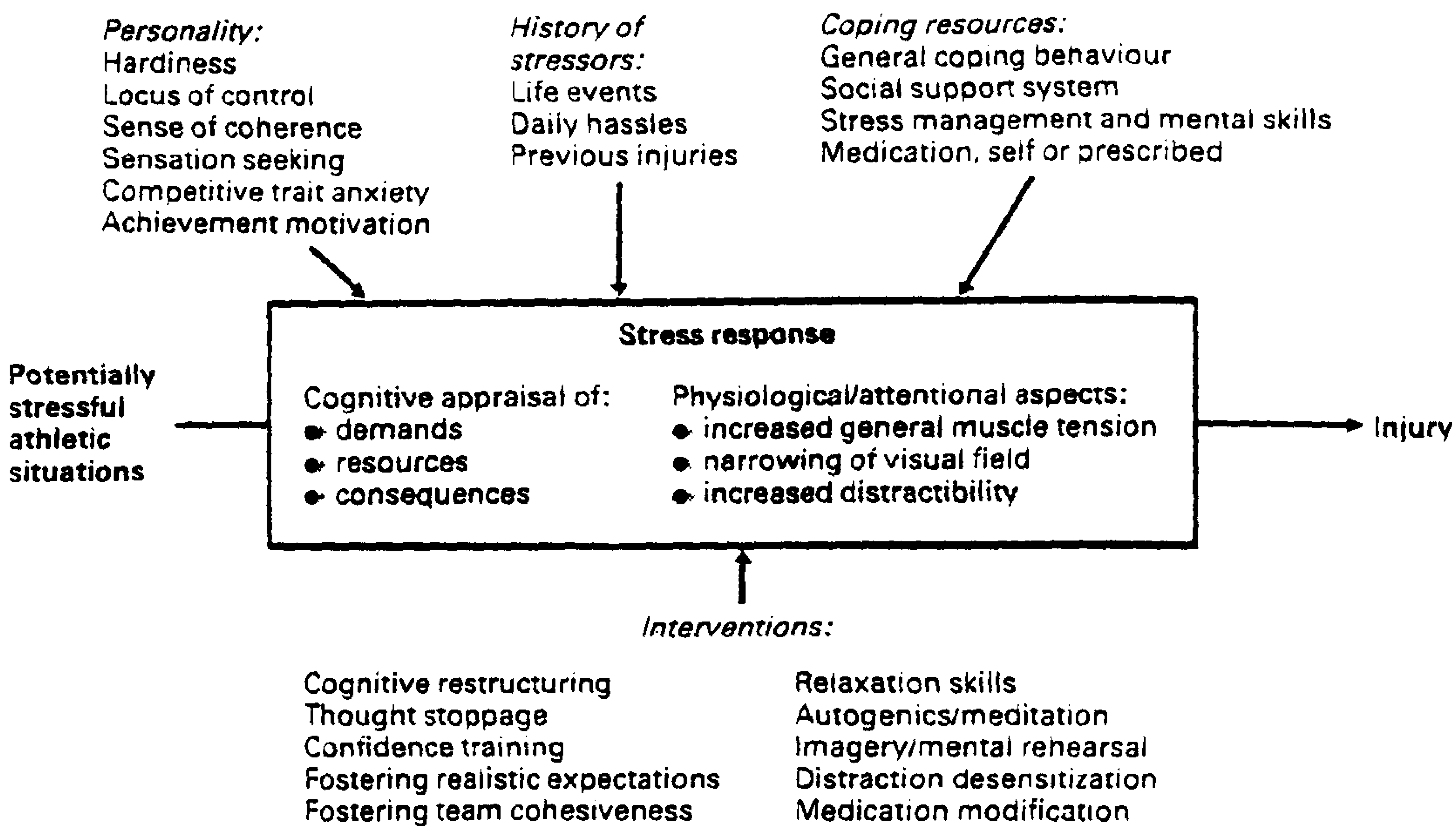
Goal setting has been recognised within the business community as a way of improving performance and controlling stress and its application to sport remains to some extent experimental, although its motivational value in the short term is clearly recognised.

Imagery would appear on balance to offer a beneficial effect to performance and mental rehearsal of particular soccer tasks is better than no practice at all. (Feltz *et al*, 1986).

Conclusion

Sports psychology is also used to control anxiety although it is recognised that a certain degree of arousal is beneficial to performance. Self confidence is another area which can be strengthened by mental exercises and motivation can be maintained by allowing players to set and achieve more difficult goals. (Bandura, 1986).

MULTIDIMENTIONAL MODEL OF STRESS AND ATHLETIC INJURY



2.4 Injury Prevention

2.4.1. Team Doctor

The Team Doctor should be a key player in any successful professional soccer team. The clubs which fail to recognise his contribution to injury prevention, team stability and ultimately success, do so at their own cost.

A team Doctor requires a specialist knowledge of Sports Medicine to provide optimal team care. He should have a detailed knowledge of Orthopaedics, Musculoskeletal Medicine and Physiology. Cardiovascular assessment, Nutrition and Psychology are also important, as well as a detailed understanding of the sport and its demands.

The Doctor is required to liase with all levels of the club structure, particularly Directors, Managers, Club Physiotherapists and Players. Different approaches are required to each of these groups and the way this is dealt with is based largely on experience. The key role of the team Doctor must be that of injury prevention, which involves not only a thorough knowledge of Sports Medicine but also the ability to apply it. Although the Club Doctor is required to establish and maintain a professional demeanour, he should not be removed from either the training field or the changing room. Ideally he should be available, personable and easy to talk to, but he should also be available for private and personal consultation, and relay a confidence in his own ability to the players themselves.

Preseason Medical

The most important role of a team physician as with any doctor/patient relationship is to establish an honest rapport. The preseason medical examination offers this opportunity. This medical should establish the general health of the player,

THE MEDICAL TEAM (from "The First 100 Years" by Bob Crampsey) whether they regard themselves as fit, whether they have had any significant previous injuries or surgery, and ascertain whether they have any special medical needs, for example asthma. The response received can then be compared with the base line assessment performed by the trainer,(as detailed in the Chapter on Functional Assessment in Soccer). A general orthopaedic examination should then be performed to assess flexibility, joint stability and alignment. Muscle weakness and imbalance or any significant biomechanical defects should be picked up at this stage. The importance of these intrinsic factors was researched by Lysholm and Wiklander (1987) who found that 40% of runners studied had some degree of intrinsic abnormality. In only 10% of cases did this appear to be related to injury.

Consultation

The consultations should be seen as an opportunity to educate players with an emphasis on diet and nutrition and how it relates directly to performance (White *et al*, 1988, Muckle 1973). Early identification of intrinsic weakness is essential as previous injury may have resulted in subtle disability. This should highlight the risk of further injury to both Player and Doctor and rehabilitation should continue even after the Player has returned to play. It is equally important to recognise relatively minor injuries which increase the risk of a second injury syndrome (King *et al*, unpublished). The team physician should also discuss with the players, their sleep pattern, alcohol and drug consumption and psychological well-being.

Injury risk is related to player personality, confidence and the individual's expression of aggression. (Nilsson *et al*, (1986) concluded that injury prone individuals tend to be excessively critical of themselves and have a tendency to continue to overtrain against advice.

Training

Medical supervision is required during preseason training and during periods of increased training frequency and intensity in an attempt to appreciate some of the wider aspects of injury prevention. The Doctor should agree with both trainer and manager upon the desired training objectives and should re-emphasise the importance of injury prevention. Prevention would include a medical input into the warm up, stretching routines and cooling down periods (Safran et al 1988). Cooling down is to facilitate training adaptation, to improve mobility and some would argue to enhance psychological, neurological, endocrinological and immunological states of health (Liesen and Hollman, 1981).

Infection

The soccer player as with any professional sportsman involved with contact sport is potentially at risk from Hepatitis B Virus (HBV) and Human Immunodefficiency Virus (HIV). The transmission of infection may occur by inoculation or contamination of a mucus membrane or broken skin by infected body fluids. This concern is not purely theoretical and has been borne out by recent case involving the transmission of HIV during a blood fight (Ippolito *et al*, 1994) and since hepatitis B virus is considerably more infectious than the HIV the corresponding risk is proportionally higher. The current opinion that Hepatitis B virus is more infectious comes from the literature on needle stick injury. Scully and Porter in 1991 suggested that the risk of developing Hepatitis B virus after a needle stick injury was as high as 35% while Finch (1978) estimated the risk of developing HIV after a similar exposure was 0.5%. The crucial distinction between these potentially lethal blood borne infectious diseases, is that vaccination for Hepatitis B virus is readily available. HBV although rarely deadly can give rise to chronic debilitating illness. Soccer players who have had Hepatitis may well recover but remain carriers and other players may have become carriers without realising.

Obviously the incidence varies geographically, with higher levels found in young adults who are sexually active especially in urban areas. This particular subgroup correlates highly with soccer players.

Recommendation

Team Doctors should be aware that clinical suspicion is an ineffective means of identifying players at risk (Kellen *et al*, 1988) and therefore occupational hazards in contact sports demand the routine use of universal precautions to minimise any unnecessary risk of infection.

Precautions for players should include strict personal hygiene, especially within the dressing room; and all clothing, equipment and surfaces contaminated with blood should be treated as potentially infectious. Players with prior evidence of disease should be encouraged to seek confidential advice from the Club Doctor and routine Hepatitis B vaccination should be recommended. (This is not the current position of the Football Association).

Confidentiality

Consideration of the transmission of potentially life threatening infections in soccer raises various medico-legal and ethical dilemmas (McConnell and MacKay, 1995). It is important to consider the legal position when the Team Doctor is faced with the situation where a Player is a HBV carrier yet is unwilling to disclose this information either to fellow players or other medical officials who may well be involved with his treatment. The Team Doctor as with all healthcare professionals owes a common law duty of confidentiality, but unlike employees of health authorities and trusts, the Team Doctor is not bound by the statutory duty of confidentiality specified in the NHS (venereal disease) regulations, 1974 nor by the National Health Service Trust (venereal disease) directions 1991. The position of the General Medical Council remains as specified in Rule 81 (g) which states "rarely disclosure may be justified on the grounds that it is in the public interest which in certain circumstances, for example, investigations by Police of a grave or a very serious crime, might override the Doctor's duty to maintain the patient's confidence."

The question is whether a Doctor would be regarded as negligent if he had not protected another member of the team to whom he also shared a duty of care. This medico-legal dilemma exists for all Doctors involved in sport and the legal interpretation remains untested in Court. We must assume that the players' confidentiality should be paramount above all other considerations of duty of care to team mates, or even fellow professionals should an infected player be transferred. The responsibility of the Club Doctor clearly demands that universal precautions are adhered to and that routine Hepatitis B vaccination should be strongly encouraged. Screening has been suggested but this does not resolve the dilemma. Screening gives rise to concerns regarding false security (Fournier and Zeppa, 1989), the need for consent and confidentiality (Cobb, 1987) and uncertainty over the frequency of testing.

On a practical note the soccer club is the employer under Regulation 12 of the Health and Safety at Work Act 1989, and with regard to the control of substances hazardous to health, is required to provide information, instruction and training to employees (players) so that they understand the risk to health posed by such substances. The act also require the correct precautions which, with regard to body fluids, may be interpreted as providing appropriate vaccination and universal hygiene precautions. One important difference between the general public and the soccer player is the fact that the player should be aware of the health risks of his particular sport, and his decision to participate should be based upon informed consent.

The Team Doctor's failure to advise and recommend vaccination for Hepatitis B, should a player subsequently become infected through occupational exposure may lead to liability. The honorary status of many Team Doctors offers no immunity to the laws of negligence (McConnell and MacKay, 1995).

2.4.2. Musculoskeletal Pathophysiology

2.4.2.1. Bone

Basic Science

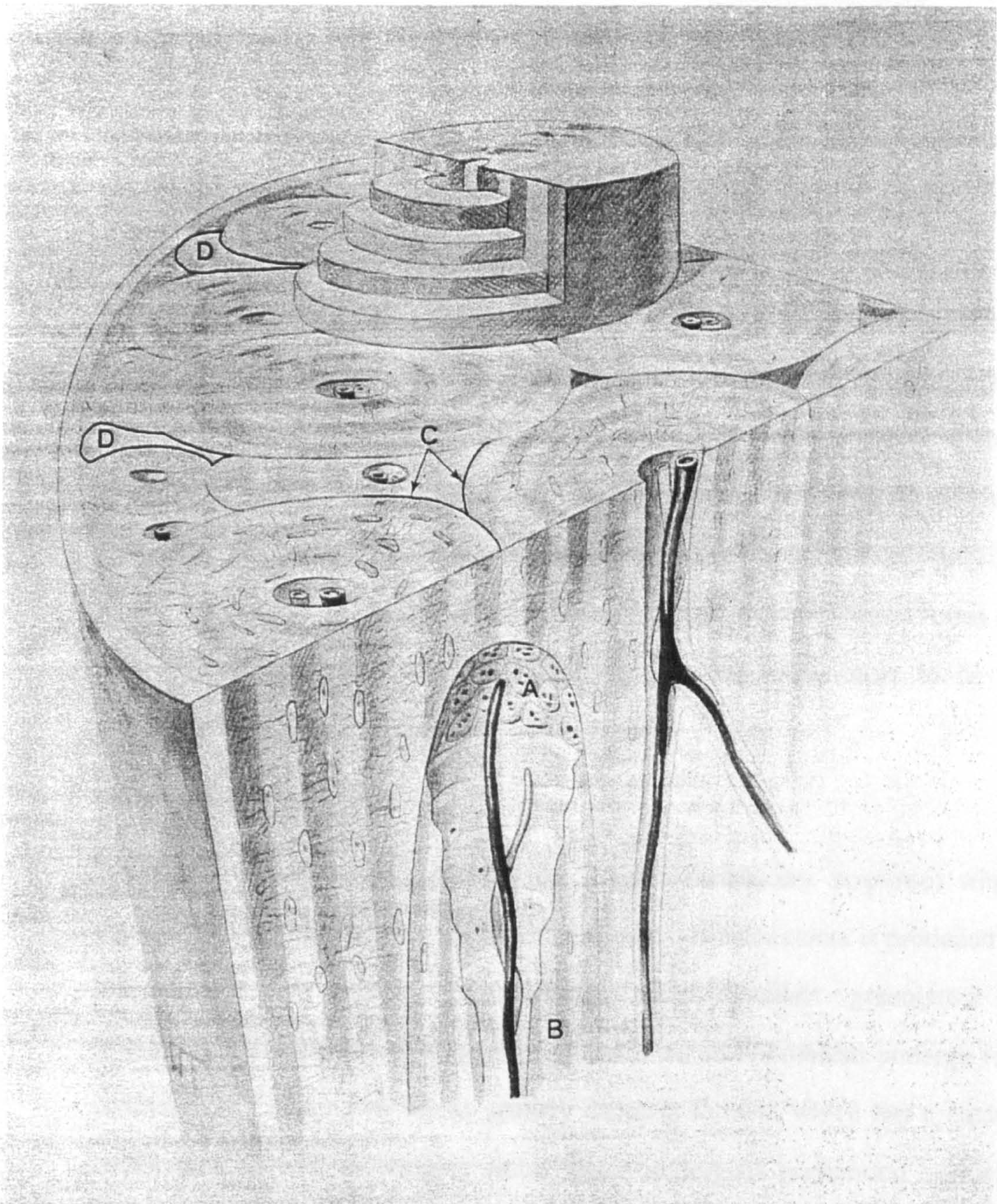
The normal structure of bone is lamellar, or woven. (Woven bone usually represents immature or pathological bone). Lamellar bone is stronger and less flexible, with fewer osteocytes than woven bone. Compact bone is composed of haversian systems, which are connected by haversian canals. (see illustration). These canals permit the passage of vessels, nerves, osteoblasts and nutrition. Cancellous bone in contrast is less dense than cortical bone and undergoes remodelling, according to the lines of stress (Wolff's Law.). Therefore, cancellous bone has a higher turnover and smaller Young's modulus, but more elasticity than cortical bone.

At a cellular level, bone is composed of; osteoblasts which are derived from undifferentiated mesenchymal cells, osteocytes which make up 90% of the mature skeletal cells and osteoclasts which are multinucleate irregular giant cells which originate from hematopoietic tissue. There is a cellular balance in bone, which has an important role in calcium and phosphate homeostasis and is influenced by parathyroid hormone and calcitonin. Osteoblasts have an important synthetic role, contributing secretion to the matrix and can be very metabolically active. The osteoclasts, in contrast, tend to resorb bone and respond to a variety of endocronological stimulation including; thyroid hormone, glucagon, PTH, vitamin D and prostaglandin.

Bone Matrix

The matrix of bone is composed of both organic and inorganic elements. The inorganic elements comprise 60% of the dry weight of bone, most of which is calcium hydroxyapatite and is responsible for the compressive strength of bone. The organic matrix is made up of 90% type 1 collagen with extensive crosslinking

ARCHITECTURE OF CORTICAL BONE



Segment demonstrating architecture of cortical bone. *A*, Cutting core of osteoclasts. *B*, Osteoblasts lay down new osteones. *C*, Cement lines. *D*, Interstitial lamellae. (From Owen, R., Goodfellow, J., and Bullough, P.: Scientific Foundations of Orthopaedics and Traumatology, p. 6. Philadelphia, W.B. Saunders, 1981; reprinted by permission.)

which is responsible for the bones inherent tensile strength. The remaining components include; proteoglycans which contributes to bone's compressive strength, as well as glycoproteins, phospholipids, and phosphoproteins.

Biomechanics

Bone is an active metabolic tissue and at any one point approximately 5% of skeletal bone is turning over. It is affected by the mechanical properties of Wolff's Law, although the extent to which these forces have an effect is dependent on the underlying genetic basis of the individual. The way in which bone remodels has been extensively studied. There is a negative piezoelectric force on the compressed side of bone, when stressed and an electro-positive charge which stimulates osteoclasts on the tension side of bone. Cortical bone remodels by osteoclastic tunnelling, whereas trabecular bone remodels by osteoclastic resorption, followed by the osteoblastic production of new bone. The periosteum of bone forms a skin which increases the circumferential diameter of bone, contributes to its blood supply and also is continuous with joint capsules.

Injury and Repair

Injury to bone is accompanied by an acute inflammatory response, which is associated with a predictable sequence of events. A haematoma is produced, with haemopoietic cells secreting growth factors which stimulate granulation tissue formation. Osteoblasts are subsequently stimulated and fibroblasts undergo further proliferation. After two weeks primary callus is formed, which has a medullary component, as well as bridging callus which undergoes enchondral ossification. The amount of callus is related to the immobility of the fracture site and various other components which contribute to fracture healing.

The final phase is remodelling, this is an extensive process which may take several years and once again corresponds to Wolff's Law.

Stress Fracture

A stress fracture arises in bone when the bone is subject to repetitive overload resulting in microtrauma and the biological capacity of bone to remodel and adjust has to compete with the repetitive disruption of endogenous or exogenous microtrauma. There are however two types of stress fracture; the fatigue fracture, defined as resulting from excessive load applied repetitively and the insufficiency fractures, where bone is unable to endure repetitive physiological loads. In 1855, Dr Breithaupt described a painful swollen foot, associated with marching, which in essence was the first description of stress fracture and subsequently became known as the march fracture. Jones *et al* (1989) describes how the osteoblastic activity increases to balance the resorption of bone which results secondarily to injury, when it is repetitively stressed. If this stress is not limited, eliminated or reduced, then plastic deformation can occur in the bone and possibly give rise to a stress fracture. This has been classified into five grades known as stress reactions, (Jones *et al,* 1989).

Aetiology

Various aetiological factors have been associated with the development of stress fractures. Despite a basic understanding of the biomechanics and how piezoelectric forces affect bone, the concept of strained memory has not been clearly defined. There have however been several important associations identified with stress fractures. There is a clear racial variation in stress fractures, as these occur less frequently in black races, (Brudvig *et al,* 1983) The somatotype of individual is important and larger subjects are more at risk presumably because the bone does not have the inherent strength required for the desired performance, (Taimela et al, 1990). There is a sex difference as females are 4 to 10 times as likely to sustain a stress fracture for a given activity, (Brudvig *et al,* 1983). The female situation has been compounded by associated medical issues such as anorexia and menstrual disorders. The oral contraceptive pill reduces the risk of stress fractures in female long distance runners. (Barrow and Saha, 1988). Sedentary individuals who suddenly choose to become active, are also at greater risk of sustaining a stress fracture, (Belkin *et al,* 1980).

Soccer

Various intrinsic factors, (James *et al,* 1978) such as biomechanical abnormalities and extrinsic factors, such as; training errors, playing surfaces and equipment may give rise or predispose to stress injury. Stress fractures are commonly reported in soccer players, the region most frequently affected is the tibia and fibula, although metatarsal bones are often involved. The less frequently affected regions include the femur and the pelvic ring, in particular the pubic rami. This is illustrated by the fact that prior to the World Cup in 1994, 9 of the first team players in the pool for the United States soccer team, sustained stress fractures. The metatarsals were the most affected region and several of the tibial stress fractures proved difficult to treat. They also reported that a significant percentage of those sustaining a stress injury failed to return to their pre-injury level of performance, which must act as a stimulus for further research. (Personal communication).

2.4.2.2. Cartilage

Basic Science

There are various types of cartilage within the body. There is the epiphyseal cartilage at the growth plate. Hyaline cartilage, which has specific friction and loading characteristics, forms the articular cartilage of synovial joints. Fibrocartilage, which is important with regard to sports injuries, is responsible for the attachment of tendon and ligament to bone. Fibrocartilage is also produced as a form of scar tissue when articular cartilage has been damaged.

Articular Cartilage

Sixty-five percent of articular cartilage is water, this allows for considerable deformation of the cartilage in response to stress. The redistribution of fluid contributes to its mechanical properties and also provides nutrition and lubrication in joint fluid. Damage to the integrity of cartilage increases its water content and undermines its mechanical properties and strength. Collagen represents approximately 15 to 20% articular cartilage, usually type II and contributes significantly to the cartilage's tensile strength. The proteoglycans in contrast represent approximately 10-15% of the articular cartilage and are composed of glycosaminoglycans, bound to hyaluronic acid and are responsible for compressive strength. The remaining 5% of articular cartilage is formed by chondrocytes. Chondrocytes form a stratified structure extending from the subchondral cortex to the superficial tangential zone. Chondrocytes can synthesise protein and produce collagen and proteoglycans. (See illustration).

Chondral Injury

The response to chondral injury is dependent on the depth of injury (see diagram, Noyes and Stabler, 1989) and the age of individual. As a player ages the number of chondrocytes increase and the chondrocytes no longer reproduce. Essentially,

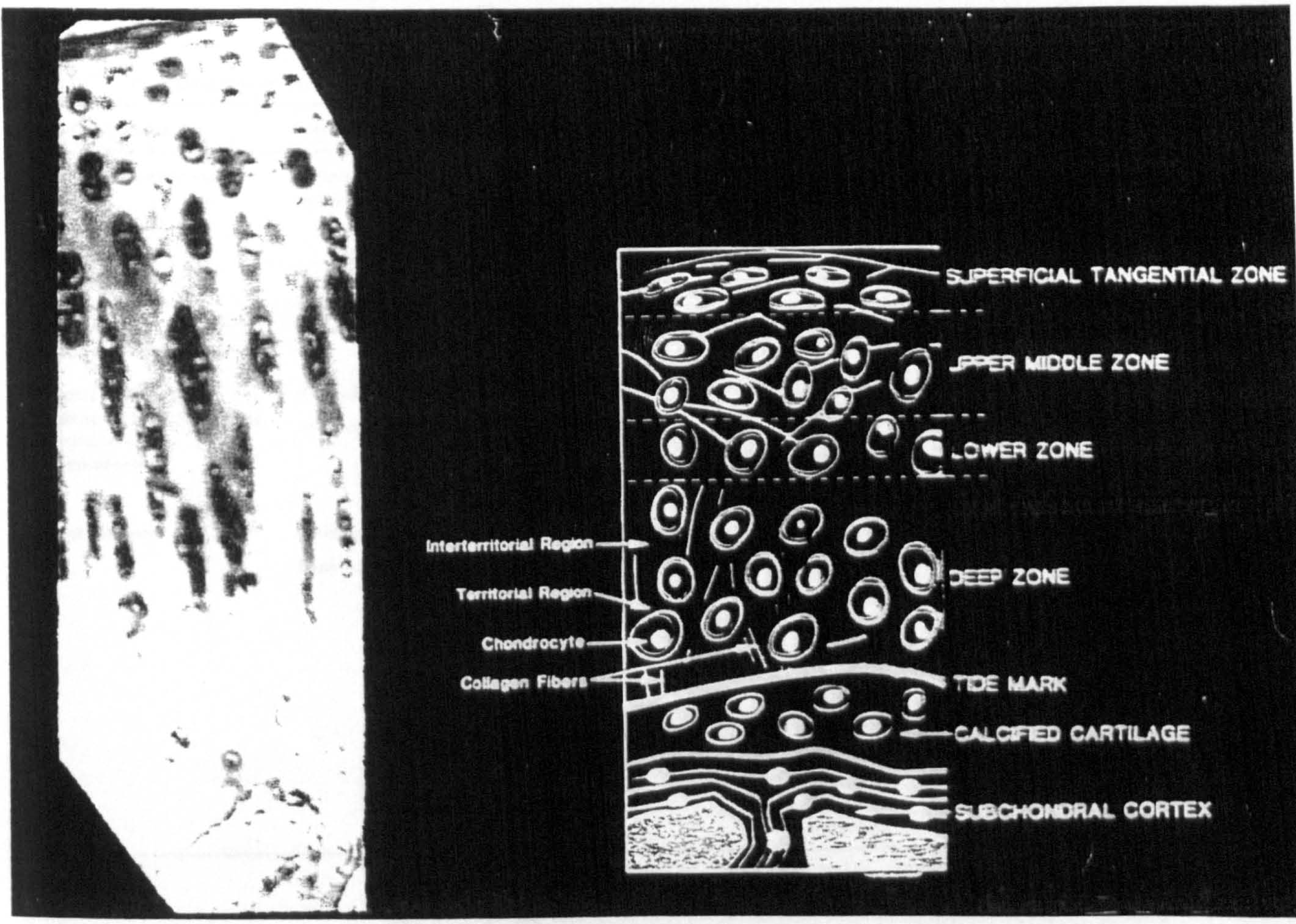


FIGURE Cartilage zones. Note gliding zone (superficial tangential zone), transitional zone (upper zone), and radial zone (lower and deep zones) above the tide mark. (From Orthopaedic Science Syllabus, p. 20. Park Ridge, IL., American Academy of Orthopaedic Surgery, 1986; reprinted by permission.)

CLASSIFICATION OF ARTICULAR CARTILAGE LESIONS

New classification of articular cartilage lesions. From Noyes & Stabler (1989).

Surface description	Extent of involvement	Diameter (mm)	Location	Degree of knee flexion
Cartilage surface intact	Definite softening with some resilience remaining	<10 ≤ 15 ≤ 20	Patella (A) proximal $\frac{1}{3}$ middle $\frac{1}{3}$ distal $\frac{1}{3}$	Degree of knee flexion where the lesion is in weight-bearing contact (e.g. 20–45°)
	Extensive softening with loss of resilience (deformation)	≤ 25 >25	Patella (B) odd facet middle facet lateral facet	
Cartilage surface damaged: cracks, fissures, fibrillation, or fragmentation	$<\frac{1}{2}$ thickness $\geq\frac{1}{2}$ thickness		Trochlea Medial femoral condyle anterior $\frac{1}{3}$ middle $\frac{1}{3}$ posterior $\frac{1}{3}$	
Bone exposed	Bone surface intact Bone surface cavitation		Trochlea Lateral femoral condyle anterior $\frac{1}{3}$ middle $\frac{1}{3}$ posterior $\frac{1}{3}$ Medial tibial condyle anterior $\frac{1}{3}$ middle $\frac{1}{3}$ posterior $\frac{1}{3}$ Lateral tibial condyle anterior $\frac{1}{3}$ middle $\frac{1}{3}$ posterior $\frac{1}{3}$	

the cartilage becomes less elastic due to a decrease in proteoglycans and an increase in keratin sulphate.

The soccer player can be exposed principally to two types of cartilage injury. Closed injury occurs when training progresses too rapidly and the articular surface is overloaded. Even with physiological loads cartilage may swell which can undermine its mechanical strength. If this condition persists, it may result in the fissuring and fracturing of the articular cartilage matrix and chondrocyte death. This may well be an early stage in the osteoarthritic process, with the release of the lysozymes from injured chondrocytes, resulting in further injury and degeneration. The importance of synovial fluid, which is produced from the synovial membrane, is recognised as any alteration in its composition or volume is associated with pathology.

Direct Injury

Direct injury to articular cartilage results in a variable healing response depending upon the degree of disruption. If cartilage injury remains superficial to the tidemark, the potential for recovery is limited. Fibroblasts are stimulated to produce collagen, which is predominantly type 2, as opposed to type 1 found in normal articular cartilage. (Furukawa *et al*, 1980). Complete articular disruption depends more upon the local inflammatory response and the degree of disruption of bone. The next stage of this progressive process of disruption, is the complete loss of an osteochondral fragment, the recovery from which can be extremely variable. Larger osteochondral fragments are resecured surgically, if this is not possible various other options have been looked at which include chondrocyte transplantation and the grafting of synthetic materials, (Bukwalter *et al*, 1990). These varying alternatives are as yet suboptimal and have not been able to reproduce the physiological properties of normal uninjured articular cartilage.

Other surgical options include local abrasion and further drilling to diminish local pain sensation and to stimulate further healing, (Johnson *et al,* 1986).

Physiotherapy is an important aspect in the recovery from musculoskeletal injury, including cartilage injury. It is postulated that continuous passive motion can facilitate cartilage repair, the initial experimental work done by De Palma *et al* (1966) concentrated on superficial injury rather than significant cartilage defects. Electromagnetic stimulation has also been found to stimulate chondrocyte activity although further research is required, (Blackwalter *et al,* 1990).

2.4.2.3. Muscle

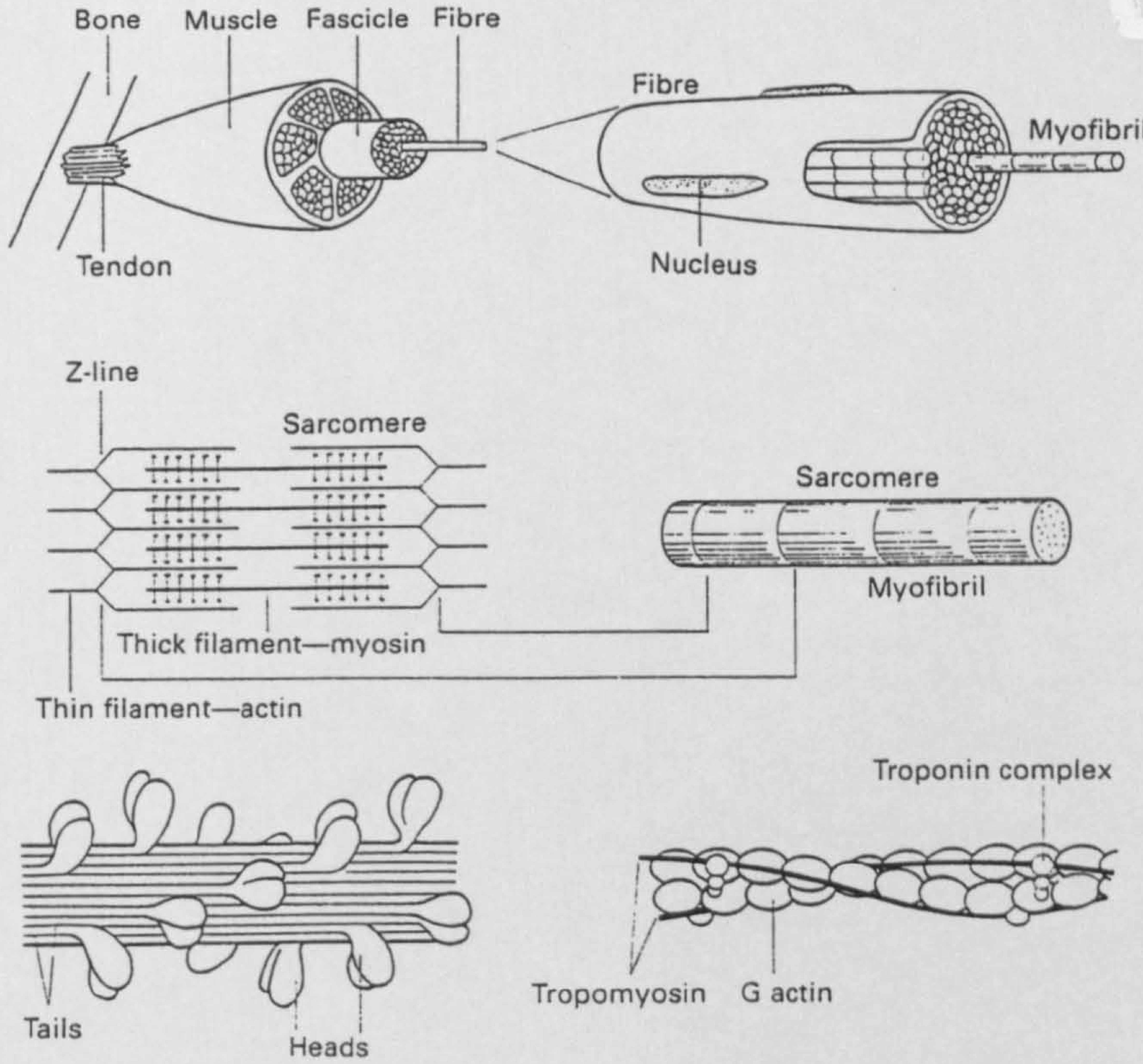
Introduction

Muscle strains are among the most common injuries in soccer and are responsible for a considerable amount of time lost from play, they also present one of the biggest challenges with regard to injury recurrence and prevention. An understanding of the basic sciences is essential, for anyone undertaking further research into muscle injury prevention..

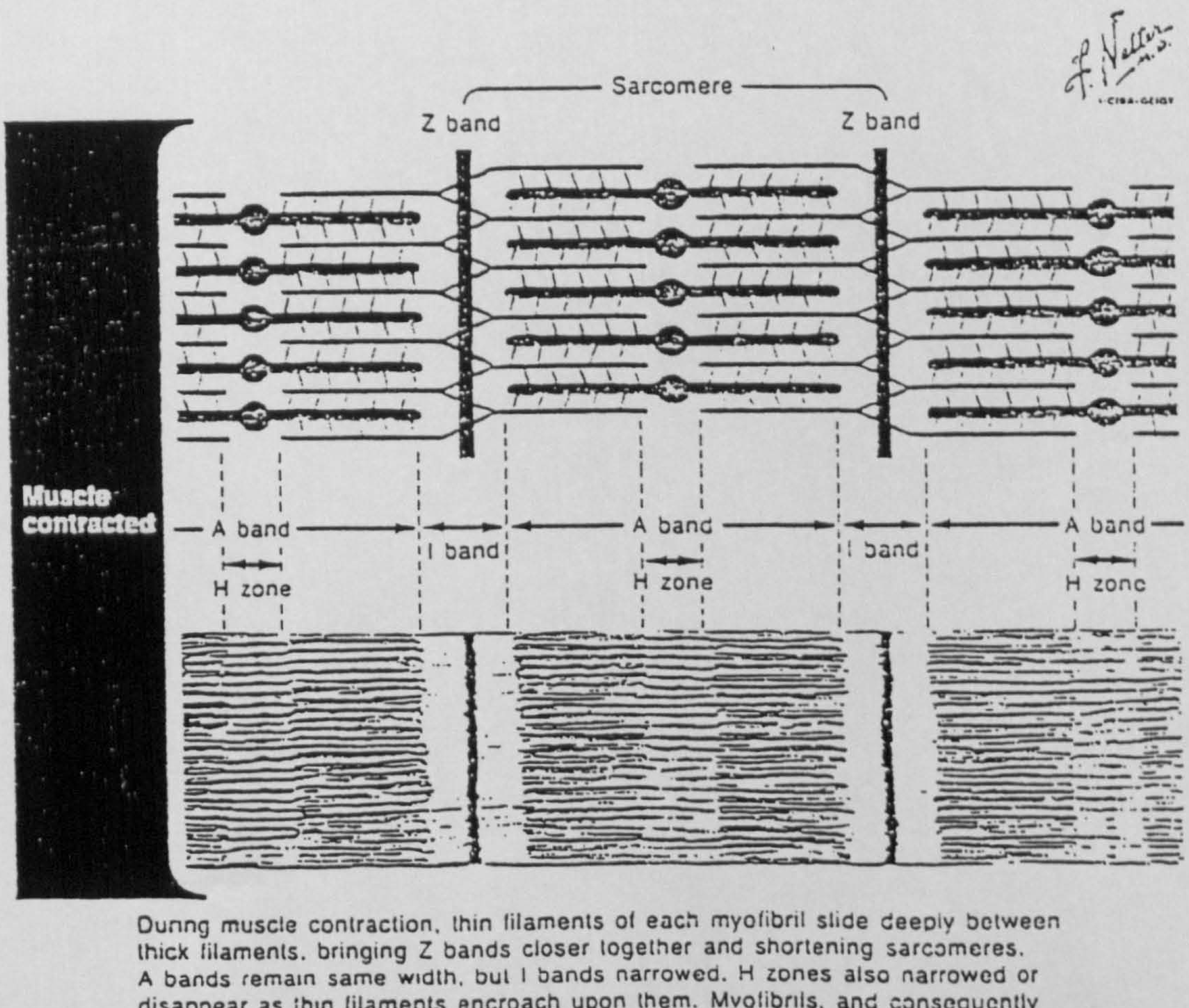
Basic Science

Muscles are composed anatomically of contractile and non-contractile elements. The non-contractile element includes the connective tissue structure of muscle, that is the epimysium, perimysium and endomysium. The musculotendinous junction represents a weak link between the filaments, interdigitating with a basement membrane and the tendon substance itself ,which is composed principally of type 1 collagen. Another important feature of the architecture of muscle is the sarcoplasmic reticulum, which is important in muscle contraction, as it provides a store for calcium.

STRUCTURE OF SKELETAL MUSCLE



The structure of skeletal muscle.



During muscle contraction, thin filaments of each myofibril slide deeply between thick filaments, bringing Z bands closer together and shortening sarcomeres. A bands remain same width, but I bands narrowed. H zones also narrowed or disappear as thin filaments encroach upon them. Myofibrils, and consequently muscle fibers (muscle cells), fascicles, and muscle as whole grow thicker. During relaxation, reverse occurs

Contractile elements

The contracile elements of muscle are constructed in a hierarchical fashion of bundles which are subdivided in sequence into fibres, myofibrils and sarcomeres. The ultrastructure of the sarcomere, involves a contractile unit of myosin, actin and troponin C. As illustrated, the filaments are attached at the Z lines and the zones are clearly differentiated.

The mechanism of muscular contraction requires action potentials to pass over a sarcolemma and into the transverse tubules; the excitation increases calcium permeability and results in the release of calcium into the sarcoplasm. When the concentration of calcium reaches 10^{-5} moles the tropomycin binds to its target protein, triponin C, the resulting change in the troponin - tropomycin complex results in movement. Relaxation of the muscle results from the active transportation of calcium into the sarcoplasmic reticulum, (Huxley, 1957).

Fibre types

Muscles can be broadly classified into two fibre types, fast and slow twitch fibres, or type 1 and type 2 fibres which are clearly differentiated by their physiological composition and metabolic activity. Type 1 fibres are fatigue resistant and have a high concentration of mitochondria and myoglobin, with a low level of glycogen and glycolytic enzymes. The Type 2a fibre is a fast twitch fibre that has intermediate characteristics, it contracts more rapidly than type 1 fibres but has moderate endurance capacity, with a relatively high level of mitochondria and myoglobin. Type 2b fibres are known as fast twitch and contract more rapidly and with more force than slow twitch fibres, deriving more energy from glycolytic processes at the expense of efficiency and are anaerobic. The variation in the type 2 fibres are based upon differences in the myosin heavy chain. A type 2c fibre is also recognised (Golnic and Saltin, 1989) which is essentially an undifferentiated fibre representing up to 10% of muscle fibres at birth but this rapidly diminishes to a residual 2% with maturity. Interestingly in athletes participating in endurance events type 2c fibres may well represent 10% of the fibres in their muscles. Having said that, elite distance runners have predominantly type 1 fibres, which are specifically adapted to maximise endurance capacity. (Saltin *et al*, 1977).

Soccer Players

For most muscles in humans there appears to be an average muscle composition of 50% slow twitch and 50% fast twitch. The overriding fibre composition is genetically determined, however, there is a degree of physiological adaptation dependant on the load put upon the various muscle groups. The soccer player requires to be fit enough to sustain activity over 90 minutes, which is varied in character, involving sustained aerobic activity equivalent to 70% of VO_2 max, interspersed with episodes of intense activity (see Chapter on Motion Characteristics). The muscle fibres in the vastus lateralis of the Swedish professional players, are composed of 59.8 ±10.6% fast twitch fibres, involving a percentage area of 65.6 ± 10.6%, which is more typical of a sprinter than a distance runner. This impression may however be slightly skewed. Bangsbo and Mizuno, (1988) studied not only the fibre distribution in soccer professionals but also the effect of deconditioning. The increased percentage of type 2 fibres in the vastus laterialis may simply reflect the demands of soccer such as kicking whereas other muscle groups such as the gastrocnemius consist of a higher proportion of slow twitch fibres. Interestingly, after three weeks of deconditioning, a reduction in type 2a fibres was identified representing a 7% reduction in fibre area. Although the numbers of other muscle fibres did not appear to diminish, the capillaries around the slow twitch fibres deteriorated.

Prevention

Muscle injuries, particularly contusions and strains, are one of the commonest injuries to present in sports and in particular soccer. (Ekstrand, 1982). Muscle strains are extremely common, especially in contact sports. They can result if muscle is distracted, often across two joints, for example, the quadriceps and the gastrocnemius. The effect of muscular action across two joints is dependent upon sensitive neuromuscular system, involving effective proprioceptive input, to facilitate co-ordination and the avoidance of excessive fatigue. (Renström, 1985). Muscle strains occur predominantly during eccentric activity and more significant pathology, in particular partial rupture, occurs primarily adjacent to musculotendinous junctions. (Garrett *et al* 1987). From the same work, it was concluded that a muscle disruption occurs when stretched to a given length, whether activated or not. If the muscle is activated, it can absorb more force and therefore muscle activation when stretched acts protectively. Two important factors can influence the susceptibility of muscle to strain injury. Muscular fatigue, which has been discussed in detail (physiology section) can significantly affect the ability of muscle to absorb energy and therefore players undertaking explosive activity, such as sprinting at the end of a training session, may well be more exposed to injury. Temperature can predispose muscle to injury and diminish performance (Astrand and Rodahl, 1977), this is closely related to the viscoelastic properties of muscle and will be described in more detail when discussing aspects of flexibility (Ekstrand, 1992, Reilly and Stirling, 1993). Certainly, warmed muscle can stretch further than cold muscle without harm.

Muscular contusion can arise from a direct contact and often results in injury to the deepest fibres of the muscle, adjacent to bone. This explanation is not as simple as it sounds. When muscle is relaxed it acts as a fluid medium and the force is conducted until it meets the interface of bone resulting in the release of energy and injury. In the contracted situation the injury is dissipated at a more superficial level, due to the resistance of contracted muscle. (Benazo *et al*, 1988). As a result of muscle injury, bleeding can give rise to a haematoma. An intermuscular haematoma occurs when blood can dissipate through interfacial and interstitial spaces. In contrast, an intramuscular haematoma occurs when blood is restricted by the intact epimysium, giving rise to pain and loss of function.

Muscular Injury

Damaged muscle has a standard method of repair. The three phases of injury repair are; acute inflammation, repair and regeneration, and finally remodelling. A full understanding of this mechanism of repair can facilitate rehabilitation, but more importantly prevent recurrence. (Renström, 1985).

1. Inflammation

As muscle is disrupted a haematoma forms and the damaged muscle undergoes a rapid process of necrosis and degeneration, resulting in a localised inflammatory reaction. Within a few days the repair phase commences with the process of phagocytosis of the debris, in an attempt to preserve the activated satellite cells and encourage the development of myoblasts. While muscle is undergoing a degree of repair, the connective tissue structures are also being replaced by proliferating fibroblasts and extracellular matrix. (Lehto et al, 1986). If this secondary process of repair is excessive, the formation of dense scar tissue occurs and this may well act as a mechanical barrier, inhibiting further regeneration of muscle.

The healing process continues with the rapid ingrowth of capillaries, to provide vital oxygen for the process of repair. It is the connective tissue element which provides this tensile strength of the scar between the opposing ends of muscle. Järvinen (1975), explained how immobilisation had a tendency to decrease these tensile property, whereas mobilisation in a controlled fashion, had a positive input stimulating muscle regeneration, capillary ingrowth and the formation of granulation issue. Järvinen in 1975 suggested that initial immobilistion may limit the amount of connective tissue reformed, as granulation tissue, at the site of muscle injury, however mobilisation thereafter will stimulate the regeneration of muscle fibres and improve their alignment.

Rehabilitation

The scientific literature provides a framework upon which experimental muscle physiology can be applied, to facilitate the process of muscle rehabilitation and repair. Painless elongation, with gentle stretching for periods of 10 to 15 seconds can be performed after approximately 3 days and this will encourage plastic deformation of scar tissue, without resulting in further disruption and retraction of the muscle ends. (Benazzo *et al*, 1989). The same paper suggests that massage should not be utilised during the first week, as this may exacerbate the muscular injury. Exercising the contralateral limb, will also facilitate the rehabilitation of injured muscle, on the affected side, (Kannus *et al*, 1992). Nerve stimulation alone will facilitate rehabilitation, as long as it is not excessive, or applied in the early stage. Laboratory work on nerve stimulated muscle (Almekinders *et al*, 1984), confirmed that normal muscle cannot be disrupted, even partially, by nerve stimulation alone. Obremskey *et al*, (1988), found that muscular strength one week after a non-disruptive muscle strain, had recovered to 77% of normal, when unstimulated, yet when activated could regenerate 90% of the normal active force. Unfortunately, if nerve injury is associated with muscular damage and there is no neurological input to the neuromuscular junction, although the muscle fibre may initially undergo a phase of regeneration, with myotube formation, ultimately the attempted repair will be fruitless and result in atrophy.

A study by Aronen *et al* (1990) has offered very promising results for immobilising quadriceps injuries in 120^{o} of flexion for the first 24 hours following injury. This study reported a reduction in duration of time between injury and return to activity from 18 days to 3.5 days.

Summary

In summary, prevention of muscular injury should be a priority for the soccer player. Conditioning will increase vascularity and muscular strength and help to avoid excessive fatigue. Training technique is important; specific strength training will increase the ability of muscle to store elastic energy. Muscle balance is significant, for example the hamstring to quadricep ratio after injury should approximate with pre-injury levels, to minimise the risk of further injury. Safran *et al*, (1989) emphasised the importance of detecting muscular weakness or imbalance, in advance. Warm up activities and stretching is required in a structured and disciplined fashion, as stretching exercises performed inappropriately can themselves give rise to injury. Stretching should be slow and pain free, whether active or passive. Muscle rehabilitation requires that the muscular strength is regained almost completely. Certainly, 90% of the pre-injury level of strength should be regained, function should be pain free and there should also be a normal range of motion before an individual is allowed to return to soccer competition.

2.4.2.4. Ligaments

Basic Sciences

The composition of skeletal ligaments obviously vary according to their location and the functional demands imposed upon them. They are composed of 65% water, by weight and 25% collagen, principally type 1, although during the process of repair type 3 collagen is often laid down and then eventually converted to type 1. Type 1 collagen is composed of elastin and proteoglycans. The proteoglycans contribute to its mechanical properties. The biomechanics of ligament function include an inherent elasticity, as well as stiffness, which increases depending upon the load applied. Ligaments demonstrate stress relaxation and are strain rate sensitive. Ligament therefore has a higher resistance when it is loaded rapidly (Akeson *et al*, 1984).

With these inherent properties ligaments can provide joint stability. This is made possible by the firm attachment of ligament to bone. Ligament gradually transforms from collagen to fibrocartilage, mineralised fibrocartilage and finally into bone. Ligaments also have an important proprioceptive role, providing sensory feedback to facilitate the fine tuning of the musculotendinous unit (Barrack *et al*, 1990).

Ligament Injury

Ligament injury is extremely common in soccer and frequently involves the ankle and knee. Ankle disruption often involves a mid-substance tear of ligament, although bony avulsion can occur. Once ligament injury has arisen regardless of the cause a standard process of repair is initiated. Acute inflammation, is associated with haematoma formation and serous fluid collects. This stimulates a local response, a cellular proliferation occurs, capillaries begin to bud, and fibroblasts become extremely active. A phase of remodelling follows as collagen is deposited, but this can be extremely slow due to the poor vascularity of ligament and it may take several months for the mechanical properties to approach the pre-injury level. For example, the lateral ligament of a soccer player will not recover its original strength after injury and as a result, will deform with physiological loads, because of the poorer stress relaxation characteristics, (Frank *et al*, 1983).

The process of ligament recovery can be facilitated by appropriate early treatment, to remove pain and prevent unnecessary swelling and local haemorrhage. Early motion is also beneficial to the process of ligament healing, if this is too vigorous or is commenced at too early a stage then the result may be detrimental. Immobilising the joint may undermine the integrity of the ligament resulting in a poorer ligament repair and associated joint stiffness, (Noyes *et al*, 1974). Freeman et al (1965) also demonstrated that propriceptive training could improve functional stability and facilitate ankle rehabilitation.

Injury Prevention

The specifics of ankle and knee injury in particular cruciate disruption will be explained more fully in the relevant section. Ankle injuries are the most common injuries in sport and that this is no different with regard to soccer. Ankle sprains constitute between 17 and 21% of soccer injuries occurring between 1.7 to 2 x 1000 hours of exposure to match play. (Ekstrand, 1994).

2.4.2.5. Tendon

Introduction

Tendon is essentially a soft tissue structure and is responsible for tethering muscle to bone. Under conditions of optimum performance it is important to maintain joint mobility, when surrounding tissues are recovering from the demands of overload or overuse. A full anatomical understanding of tendon function is required to appreciate aspects of injury prevention and to optimise rehabilitation.

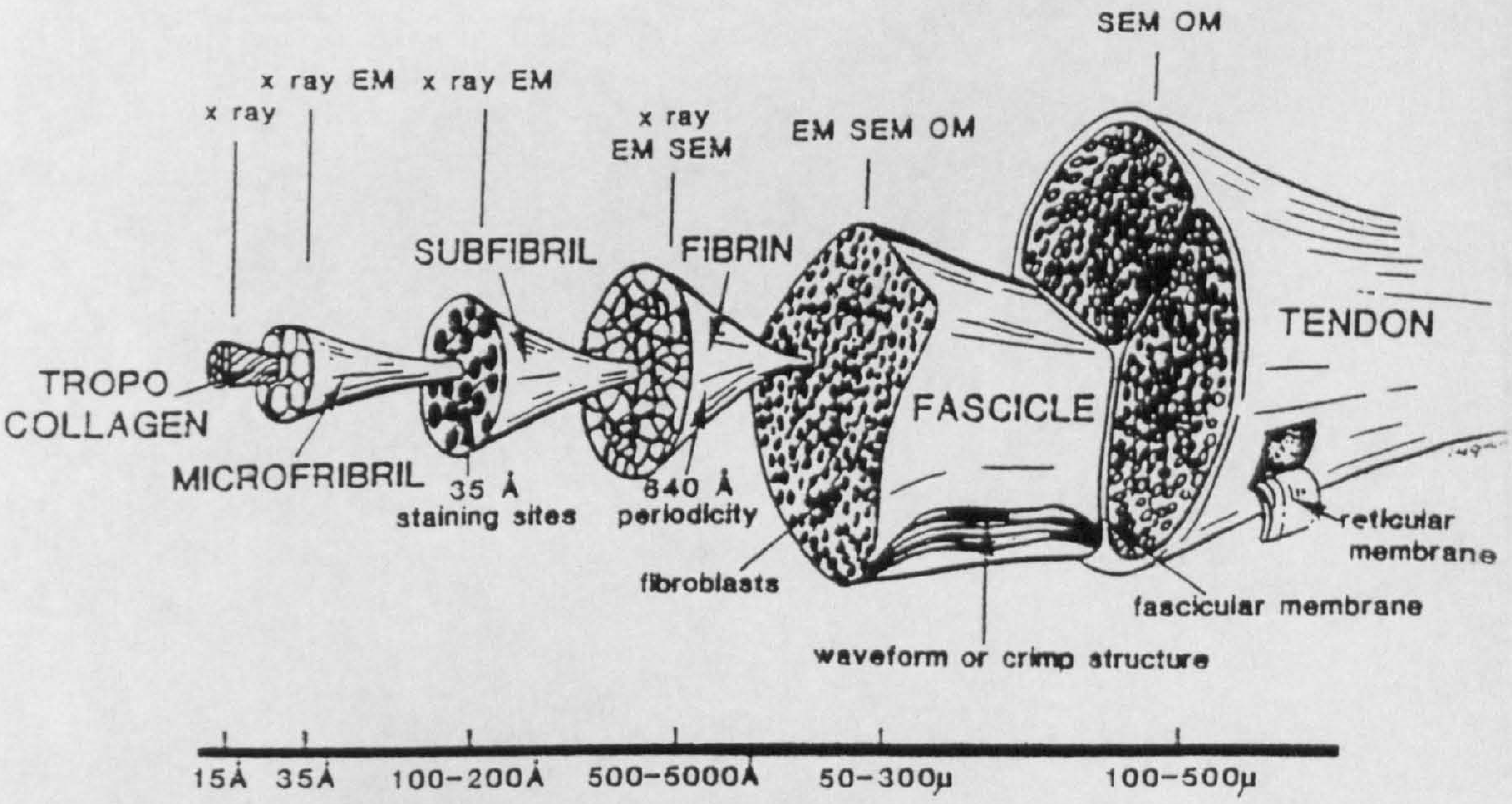
Basic Science

Tendons, as illustrated, are arranged in bundles, to attach muscle to bone. These bundles are structured in a hierarchical fashion, from the basic molecule of topocollagen (type 1 collagen). Tropocollagen molecules are grouped together to form a microfibril and subsequently as subfibril, fibrin, a fascicle and then the tendon itself. The fascicles are separated by an endotendon and surrounded by an epitenon.The tendon itself is surrounded, by a paratenon or tendon sheath. In the section attaching tendon to bone, there is a transitional zone of calcified fibrocartilage, known as Sharpie's fibres, which helps to dissipate mechanical load. Tendons are relatively avascular tissue, the blood supply provided by the paratenon is adequate to meet the nutritional needs of a tendon and for tendons surrounded by sheaths small vinculae provide the blood supply. Nutrition can also be obtained from synovial folds and periosteal attachments, as well as surrounding tissues.

Tendon Repair

Tendon repair is initiated by fibroblasts, which originate in the epitenon, and macrophages from peripheral blood. The rope like architecture of tendon at an ultra-structural level, with cross-linking between collagen molecules, contributes to its tensile strength. The cross-linking of the collagen molecules helps protect it from mechanical stress, however, this cross-linking can become excessive, for

TENDON ANATOMY



SIZE SCALE

example after a period of immobility and results in stiffer tendons with less elasticity.

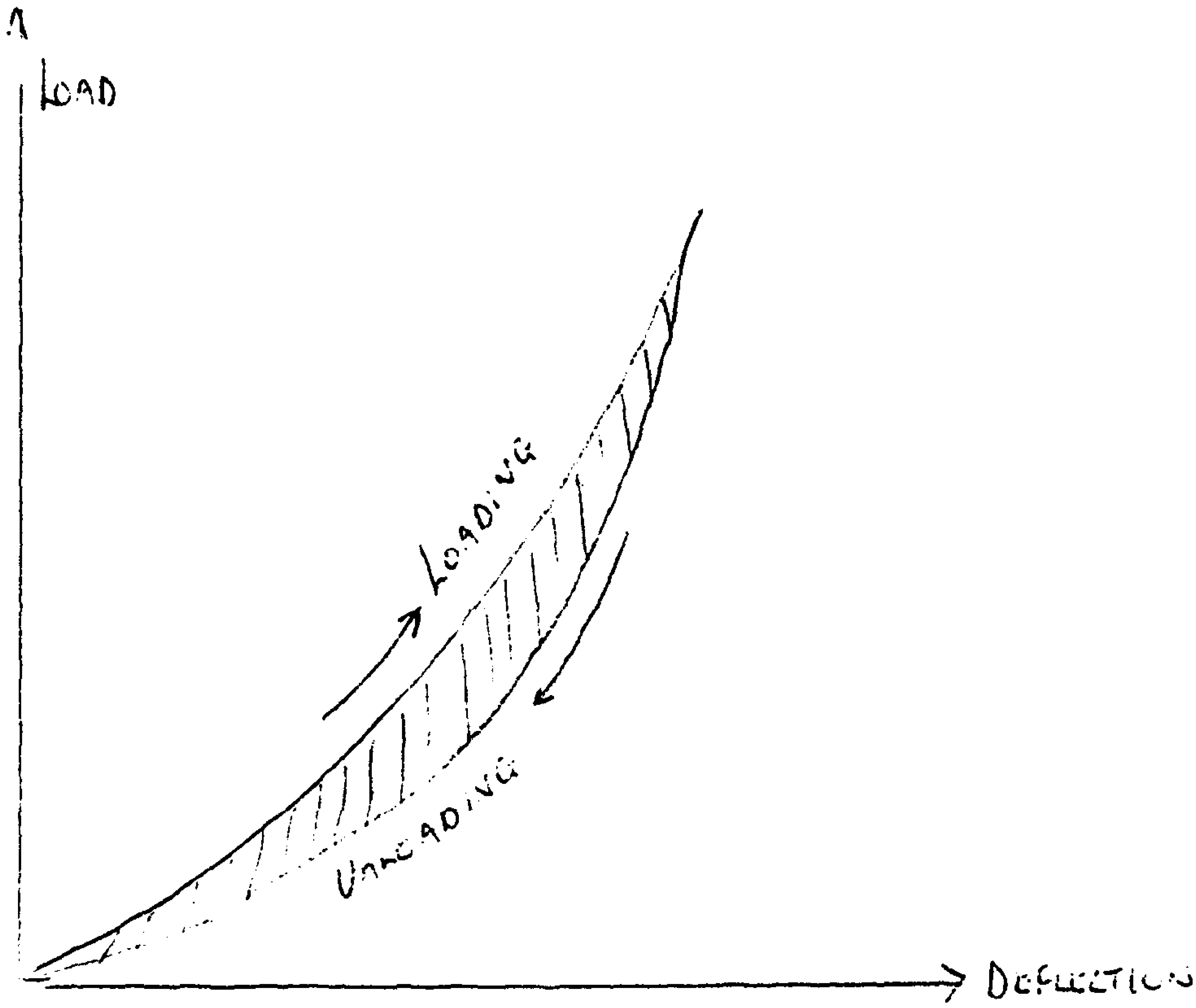
Glycosaminoglycans contribute to the ground substance of a tendon, representing 1% of its dry weight, but it is responsible for binding approximately 75% of the tendon's weight in the form of water. The inherent structure of these glycosaminoglycans can vary according to the mechanical demands opposed upon them. Compressive forces encourages synthesis of one particular type of proteoglycan, yet tensile forces encourage the synthesis of other glycosaminoglycans.

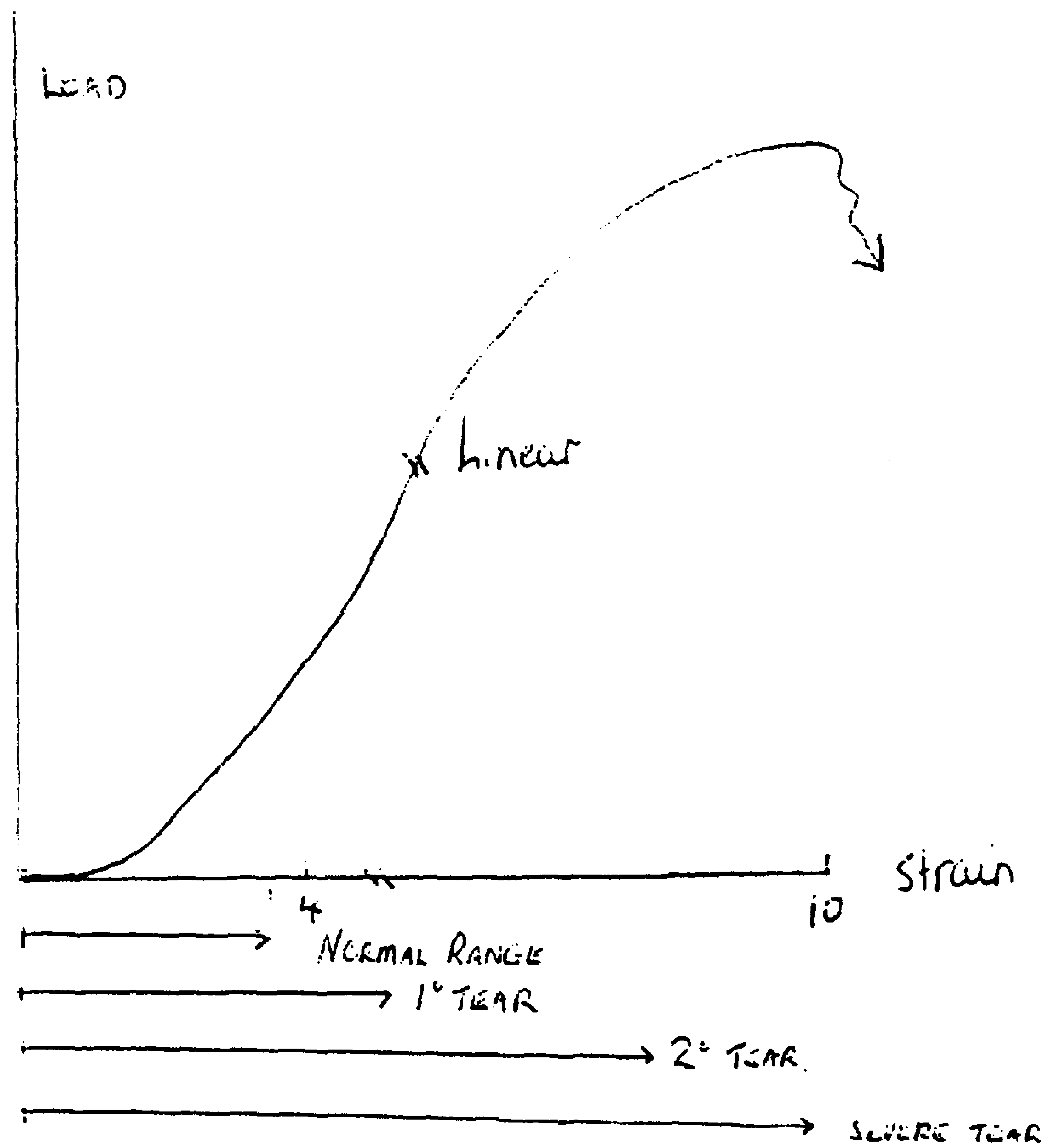
Biomechanics

The organisation of a tendon is responsible for its mechanical properties. (Butler *et al*, 1978). The resting state of a tendon allows it to adopt a crimped position contributing to its relative elasticity when low loads are applied, as illustrated, in the stress versus strain diagram. After the initial stretch of the tendon there is a linear stress strain relationship. With increasing strain, as detailed by defraction studies, there is intrafibrillar slippage and disruption of the collagen fibrils themselves. (Stevens *et al*, 1977). The stress strain curve then plateaus at this point, before the tendon completely ruptures. Tendinitis mostly arises from stresses applied in the linear region of the stress strain curve. Tendon injury results in increased molecular disruption, reducing tendon cohesion, and resulting in decreased tensile strength. Disruption occurs, not only during repetitive loading, but also after rapid unloading,(Knorzer *et al*, 1986). An understanding of this disruptive process within tendon offers a greater insight into the aetiology of tendon injury and its subsequent rupture, than *in vitro* studies, loading tendon excessively to the point of rupture.

Tendons have the ability to adapt to the stresses put upon them. Healing tendons, or normal tendon exposed to physiological loads, will hypertrophy to become

TENDON BIOMECHANICS





stronger. During exercise it is now accepted that tendons can be loaded close to their theoretical physiological limit. For example, the achilles tendon may transmit forces in excess of 4,000 Newtons while jogging, and this may increase to in excess of 8,000 Newtons, while sprinting (Curwin, 1984). It would seem logical that a tendon may be predisposed to injury, in particular the achilles tendon, if there is a sudden increase in the training load.

Prevention

Sport induced soft tissue injury and tendinitis have been extensively studied. The analogy between tendon injury and stress fractures of bone described by Clancy (1994), seems to be appropriate. Intrinsic and extrinsic factors can both contribute to tendinitis, although it is unusual for it to arise without excessive physiological load. Intrinsic factors, although less significant, may well accentuate tendon injury and delay repair. These factors have been discussed under Nutrition and include dietary deficiency of Vitamin C, which would undermine collagen synthesis and weaken the cross-linking within the tendon structure, resulting in diminished tensile strength. Immobilisation can also accelerate collagen degradation and weaken tendons, especially if the tendon has been immobilised in a relaxed position, as this will result in adaptive shortening, (Noyes *et al*, 1974). A variety of hormonal factors, such as oestrogen levels and endocrine factors may well influence the integrity of the tendon structure.

It is accepted that loading, especially if rapid excessive and repetitive, carries the highest risk of developing a tendinitis. A gradually applied force even of the same magnitude is less likely to be as injurious. The same principle applies for the removal of force. If a force is removed rapidly a greater degree of tendon disruption occurs (Knorzer *et al*, 1986). As with muscle activation the greatest tendon forces are generated during eccentric muscular contraction and this is when tendon is vulnerable and at risk of injury. (Curwin *et al*, 1984). To facilitate structured rehabilitation, it would be appropriate to classify tendon injuries scientifically. A proposed structure, offered by Clancy (1990), is as follows.

Classification of Tendon Injury

Type 1 Tenosynovitis and tenovaginitis - an inflammation of only the paratenon or synovium.

Type 2 Tendinitis - an injury or symptomatic degeneration of a tendon with a result inflammatory reaction of the surrounding paratenon

Subgroups - acute symptoms present for less than 2 weeks

- subacute symptoms present longer than 2 weeks but less than 6 weeks

- chronic symptoms persistent for greater than 6 weeks.

This would be associated with subgroups

(a) with interstitial microscopic failure

(b) central necrosis

(c) frank partial rupture

(d) acute complete rupture.

Type 3. Tendinosis - which is asymptomatic tendon degeneration due to either ageing, accumulated microtrauma or both.

Subgroups 1. Interstitial

2. Partial rupture

3. Acute rupture.

It was pointed out by Curwin (1995), that one of the major difficulties when evaluating chronic tendinitis, had been the lack of a suitable animal model.

Blackman *et al* (1990) used a rabbit model for the study of chronic tendinitis, which provided a new insight into the histology of tendon inflammation and confirmed that thickening of the paratenon is associated with an increased blood flow, to both paratenon and tendon. Most of the inflammatory cell response was restricted to the tendon sheath, with degenerative changes in the central portion of the tendon. This was the first model to produce tendon dysfunction, through reproducible loading. The conclusion from this work was that contrary to the previous held opinion, it is unlikely that central degeneration and tendinosis occurs in isolation without a surrounding inflammatory response affecting the paratenon. It suggests that adequate treatment should be directed toward eliminating any intrinsic or extrinsic factors which may predispose to injury as well as providing effective treatment for the inflamed tendon. A tight musculotendinous unit increases the risk of tendinitis, as will excessive pronation of the foot, resulting in a greater twist and strain on the medial portion of the achilles tendon and tibialis posterior (Clancy, 1994).

One treatment worth special mention is ultrasound, which is a commonly used modality for the treatment of tendinitis in general and in particular achilles tendinitis, in the professional football player. There has been considerable debate over the quality of research used to justify its use in various stages of the healing process. Ultrasound is thought to have little or no effect on the inflammatory response, except that associated with thermal injury, although, it has been shown to increase collagen synthesis by fibroblasts and speed wound healing (Dyson *et al*, 1978, Harvey *et al*, 1975). The net result of the effective and appropriate use of ultrasound should be to improve the tensile strength of repairing tendon, (Enwemeka *et al*, 1989).

2.4.3. Stretching: Warming Up and Warming Down.

The routine of warm up and cooling down periods, have now become an accepted part of the training regime, in soccer and is usually associated with a combination of stretching routines. They are important in optimising performance, as well as preventing injury.

The warm up usually comprises a period of 15 to 20 minutes of activity. The physiological benefits of such a routine are well understood. It is known that on a cellular level, the warm up results in an increased temperature, which facilitates oxygen dissociation and the release of oxygen from myoglobin. This was taken further by Astrand and Rodahl (1977), who stated that a one degree increase in temperature of muscle enhanced the metabolic process of the cells by approximately 13%.

The cardiovascular system is also primed through a warm up, by increasing the cardiac output and heart rate and enabling blood to be diverted, to meet the metabolic demands of the muscles involved. This increased blood flow also perfuses the skin, to facilitate thermal regulation. Nadel (1977), suggested that intensive exercise could increase the basic metabolic rate in muscle, by an order of 15, which in absence of thermal regulatory measures, would result in an elevation of the core temperature by approximately 1^{o}C, every 5 minutes. The respiratory centre is stimulated by a variety of inputs during the warm up phase, including; proprioceptive inputs from joints, golgi tendon organ, etc. This respiratory stimulation increases oxygen consumption, by reducing the demand for anaerobic metabolism. This in effect increases the work capacity of muscle, by diminishing lactic acid accumulation at the onset of exercise.

The net result of the warm up, is that it should facilitate athletic performance (Davies and Young, 1983). By increasing the temperature of muscle, by as little as

3.1°, is possible to decrease the contraction time by 7% and speed up the muscle relaxation, by 22%. In contrast, a decrease in muscular temperature by 8.4°, can increase the contraction time by as much as 38%. Warming muscle not only enhances nerve conduction, but also reduces the sensitivity of the alpha motor neurone from the muscle spindles and therefore increases the threshold for the stretch receptors (Kulund and Tottosy, 1983). Noonan *et al*, (1991) suggested that Cold muscles are more prone to injury due to increased stiffness. Unfortunately, clinical studies addressing injury prevention, have tended to be confused by multiple variables and the topic remains open to discussion. Clear clinical benefits in performance have been described in a controlled setting as Sargeant (1983), demonstrated that the peak power production for cycling, could be improved by 4%, by increasing the muscular temperature by 1°C.

Cooling Down

The cool down period appears to be a logical way of finishing a period of relatively intense exertion. Ekstrand (1983b) concluded that a routine cool down period could reduce the number of injuries in professional soccer players. This period allows homeostasis to be re-established at a metabolic level, facilitating lactate transportation and breakdown. The cool down period can also be regarded as a period of active regeneration, to facilitate and some would argue to maximise training adaptation. It is also a stress free period and may well have a psychoregulatory role, after the stress of intensive exertion. (Liesen and Holeman, 1981).

Stretching

Stretching is of considerable importance for three reasons; to maximise performance, to prevent injury, and to facilitate rehabilitation.. Muscle tightness has been identified as a predisposing cause of injury in soccer, (Ekstrand and Gillquist 1982, 1983d). They found that 63% of Swedish fourth division players (mean age 24.6 years), had muscle tightness affecting the major muscle groups of lower limb. The hip flexors were the only group to be found within the normal range when compared with the age match controls. In the above study, muscle tightness was thought to account for 11% (28) of all reported injuries (n= 256).

The viscoelastic properties of biological tissues can be affected by the frequency, duration and intensity of load applied. It was Qureton (1941), who suggested that stretching and improved flexibility may minimise injury, by strengthening and improving the elasticity of musculotendinous units. The concept of stretching was based on a neurophysiological understanding of the stretch free flex (Prentice 1983). This theory has since been questioned and Cole *et al* (1991), point out that established that the mechanical changes brought about by stretching, can occur independently of nervous activity. Currently, the recommended stretch is based on proprioceptive neuromuscular facilitation (PNF). The principle is that a pre-stretch contraction of muscle, will fire golgi tendon organs and result in muscle relaxation. This is also important for antagonist muscle group, as they may impair co-ordinated movement and increase the risk of injury. It is now agreed that relaxed stretching techniques are the safest way to increase muscle flexibility.

In essence, stretching is focused on the viscoelastic tissues to produce creep and this effect is maximised by a slowly applied but maintained force (Kolthe *et al*, 1966). An understanding of dynamic muscle action and the associated stretch reflex ,which responds to both sustained and explosive stretching, is important. It is the golgi tendon organ and the inverse stretch mechanism which has to be fully understood to appreciate the stretching techniques and inturn, the areas most frequently injured (Garrett *et al*, 1990). The golgi tendon organs, which are positioned close to the musculotendinous junction, can override the stretch reflex, resulting in muscular inhibition. Various studies have established the musculotendinous junction, as the most vulnerable muscular zone. Certainly, the musculotendinous junction differs anatomically and is less extensible, than other areas of the muscle. (Garrett, 1990).

2.4.4. Sports Equipment

Introduction

The soccer player, in common with any athlete, is subjected to a variety of forces which can be assessed biomechanically. Understandably, internal and external forces can be influenced by the movements undertaken by the soccer player and some of the basic biomechanical principles are worth emphasising. Biological tissues are not inert and change and adapt according to the functional mode applied. Overall inherent strengths can be affected by; exercise, immobilisation, stretching and ageing. Certain biological tissues, such as cartilage, can withstand greater forces when a single load is applied, however, this limit can be reached at a lower threshold if the tissue is subjected to repetitive loading. (Mow and Rosenwasser, 1987). The resting time, as well as the frequency of repetition, is important. For the elite player, this may represent a crucial balance between a positive or a negative training stimulus. Nigg (1990) reviewed this in some detail.

Playing Surfaces

Although only one team included in my study played on astroturf, as opposed to grass, it is worth noting that the playing surface can contribute significantly to the injury frequency. Nigg and Denoth (1980) have shown that the playing surface can increase injury frequency, by four-fold for selected activities. For example, in tennis the injury frequency for surfaces which do not allow sliding, is at least 200% more than for surfaces that do allow sliding, such as clay and synthetic sand. This difference has not been so clearly established for soccer. Soccer epidemiology remains difficult to interpret due to differences in injury classification, control and follow up. A review of playing surface related injuries by the NCAA Injuries Surveillance System (1991), reported that in male soccer, there were 26% of injuries on natural grass and 28% on artificial turf. The match situation was comparable, with 22% of injuries resulting from those played on natural grass and 28% of those played on artificial grass.

The most important factor, with regard to injury frequency is the frictional behaviour of artificial surfaces. Ideally a surface should provide a degree of sliding, yet enable a player to maintain sufficient traction to keep his balance. Other aspects such as cushioning of artificial surfaces have been investigated but appear to be less significant.

Footwear

The importance of the soccer boot has generally been overlooked, in most studies addressing the aetiology of soccer injury. This may relate to the fact that players are particularly fussy when choosing football boots, as they regard their footwear as a finely honed aspect of their craft, akin to a virtuoso's violin. Footwear, as is the case in other sports, may well represent an important factor in the development of overuse injuries, such as; medial tibial periositis, achilles tendinitis and plantar fasciitis. Studies of American football have found a positive association between larger studs and injury. A well designed study by Luethi (1986), using two different shoe models, confirmed that the type of sports shoe related directly to the site, type and frequency of certain sports injuries.

Nigg (1990) assessed the importance of footwear construction and its effect on internal and external forces. Heel flair, for example, influences pronation and supination during landing. Heel stabilisers increase the initial pronation on impact of forefoot and decrease some of the vertical forces applied. The torsional stiffness of a shoe, increases the load on isolated ankle ligaments, resulting in their subsequent elongation (Morloch, 1990). Overuse injury can be reduced by the use of appropriate insoles and suitable football boots (Jörgensen, 1989) and by gradually adapting to new surfaces, which should be tailored to provide optimal frictional resistance.

2.4.5. Drug Misuse in Soccer

Professionalism

In Scottish football the Corinthian ideals of amateurism, were immediately threatened by the prospect of players seeking to win at all costs. Although the first recorded professional transaction in Scottish football, occurred when Ross was transferred from Dunfermline to St Bernards in 1890, soccer remarkably, has remained relatively free from performance enhancing controversies.

Drug Regulations

FIFA have strict drug control regulations which are in line with those of the International Olympic Committee. Testing can be carried out at any match taking part in any of its affiliated competitions. Ninety minutes before kick off the Team Doctor is expected to present a list of current medication in the form of a Physician's certificate, detailing any medication consumed within the previous 48 hours. Two players per team are then drawn randomly 15 minutes before the end of the game, in a supervised condition. The samples are given once the player's identity has been checked, through a doping control doctor. The samples provided are then analysed in laboratories, officially accredited by the IOC and conclusions are not drawn from the sample, until positive results are yielded from both tests. Some of the key points which may relate to subsequent injury is that alcohol and marijuana are not prohibited, although they may be tested for. Local anaesthetics can also be administered under clearly specified conditions, which are considered to be medically justified. Steroids can also be injected, used topically or even inhaled for anti-inflammatory reasons, although it is recognised that the stimulant and euphoric effect of the steroid, may well enhance performance.

History

It is of general interest that in the Panathenaic Games it was believed that the sweat of a successful champion, could enhance the performance of other participants. Therefore, after competition sweat was often mixed with powdered dust and oil which formed an adherent strip called a "strigilo". In essence, at least in theory, this was a very early form of doping.

It would appear from a review of the literature that doping does exist in soccer but this incidence is relatively low compared with other sports. Specific events are well known for their doping controversies, such as; weight lifting, athletics and even cycling. As early as 1932, the cycling fraternity were experimenting with various performance enhancing cocktails, including; caffeine, cocaine and strychnine. In soccer, the commonest offending substances are pseudoephidrine and anabolic steroids, in particular testosterone. In summary, it would appear that banned substances for enhancing performance appear to be under control and a large publicity campaign, is currently under way, to highlight the dangers of the use of recreational drugs among youth players, as with the youth at large.

2.4.6. Refereeing

Refereeing is a difficult and demanding task and the referee can make a significant contribution to minimising the consequences of injury and indeed their prevention. It remains the role of the referee to determine whether an injury requires treatment on the field. The decision can be extremely important and a greater understanding of sports medicine should be emphasised in the continuing education of official referees.

A)

B)

Rules

The rules of football are clearly established, but modifications do occur from time to time, although the motive is not always injury prevention. They may relate more to economic considerations, such as; television coverage and public pressure. The referee should apply the rules strictly, to ensure fair play and to protect players generally. Gillquist and Ekstrand (1983d) found that 12%(31) of the soccer injuries, reported in a year long prospective study of 180 senior amateur soccer players, could be attributed at least in part to foul play. It is therefore the referee's responsibility to apply the rules correctly and prevent hazardous collisions, such as tackling from behind.

Another area of controversy has been the restricted use of substitutes, which often forces a player to continue playing for the greater good of the team, even when injured. Jörgensen (1989) carried out a controlled study looking at the use of free substitution and found that this could reduce the duration of minor injuries by providing early assessment and rehabilitation. The risk of second injury syndrome was also minimised (Renström, 1994).

Consent

Mens sana in corpore sano, or a healthy mind in a healthy body, is the classical aim of both sport and medicine. The recent focus on violent injuries in soccer and the exponential increase in medical litigation suggests that this relationship is no longer so clearly defined.

Violente non fit injuria, he who voluntary consents to lawful risk, cannot later claim compensation in the event that the consequences inherent in the risk become reality. This legal principle has served to keep the involvement of law in soccer to a minimum but there is a limit expressed succinctly by Professor Bernard Knight, "deliberate criminally and civally actionable breaches of play law nullify the legal disclaimer noted above. For consent to be legally valid it must be both informed and freely given."

The clear message for soccer players is that, although they consent to the innocent risks associated with fair play, this consent must be informed and furthermore they are still protected by, and must act within, the normal restrictions of criminal and civil law. Ignorance of these restrictions is no defence in criminal law: *ignorantia iuris nomenonen excusat.* The English Court of Appeal's criminal decision with reference to R -v- Venner, 1975 supported the view that unlawful force applied recklessly constitutes assault, a decision which would be very persuasive in Scots criminal law.

It is questionable whether soccer players are aware of the risks and consequences of injury. Some indications emerge from the report of Windsor Insurance for the Football Association, in 1988. It stated that a third more players were forced out of the game through injury, than a decade ago. The criminal compensation scheme also referred to the problem of criminal acts in sport. In 1980, paragraph 30 stated in relation to soccer: " we doubt that the public are aware of the catastrophic effects which result from such criminal acts"; this statement referred to the impact in areas such as family, employment, etc. (McConnell and MacKay, 1995).

Although the legal position of consent in soccer awaits clarification, it is clear that the law does not stop at the touch line and an awareness of this situation among players, may well help to prevent injury, although excessive Police involvement within contact sport is fraught with difficulties, as recently illustrated by several high profile cases.

X-RAY

MR A MCGRAW (WITH PERMISSION) MANAGER AND FORMER PLAYER OF MORTON F.C. SUFFERS FROM CHRONIC KNEE PAIN. HE REQUIRED FREQUENT STEROID INJECTIONS THROUGHOUT HIS PLAYING CAREER.

2.5 Soccer Injury Epidemiology

2.5.1. Introduction

Soccer injuries are probably the commonest sports injury in the world. This is a reflection of the sports popularity, with as many as 150 million participants world-wide, rather than of the inherent dangers of the sport itself. As early as 1977 Franke reported that 50 to 60% of all sports injuries in Europe and 3.5 to 10% of all hospital treated injuries, were due to soccer. (Ekstrand 1982, Keller *et al*, 1987). Despite the game's popularity, there have been relatively few well structured epidemiological studies specifically assessing soccer injuries. The table opposite structured by Lohnes *et al* (1994a) summarises the findings of 20 studies undertaken between 1978 and 1990. It is clear that Scandinavia and the United States have been active within this research field, but only one small study by Hunt and Fulford (1990), was included from the UK. This British study reviewed 200 amateur soccer players consecutively attending the accident Department of King's College Hospital.

The heterogeneity of table 1 highlights the difficulty in interpreting pooled results. Epidemiological data comes from a wide variety of geographical regions with differing climates and conditions, as well as; league structures, style of play and level of competition. For example, Hoy *et al* (1992) addressed European soccer injuries but this included both male and female players (715) who attended the Emergency Department of Randers city Hospital Demark. Blackous *et al* (1988), studied soccer injuries specifically in children (6-17years) participating in soccer camps in the United States. Albert (1983) studied 56 professional players for five seasons(three outdoor and two indoor seasons from 1979 to 1982), while McMaster and Walters (1978) carried out a similar study for a fall season (which lasted for only four months), both researchers were based in the States.

Table I EPIDEMIOLOGICAL STUDIES OF SOCCER

Epidemiological Studies of Soccer Injuries

Year	Country	Age	Sex	Population Size	Total Injuries	Injury Rate (per 1000 hr)
1983	United States	Professionals	M	56	142	—
1988	United States	6–17	M	681	109	7.3
			F	458	107	10.6
1986	France	10–35	M	123,175	6,153	1.7
1986	United States	—	M/F	—	111	—
1983	Sweden	17–38	M	180	256	—
1991	Sweden	16–28	F	41	78	—
1986	United States	8–16	M/F	455 (outdoor)	46	—
				587 (indoor)	74	—
1992	Denmark	5–54	M/F	—	715	—
1990	UK	10–45	M	—	200	—
1986	Norway	12–18	M/F	14,800	411	11.7 total 17.6 female 8.9 male
1973	United States	—	M	15	60	—
1991	United States	17–22	M	—	1,221	7.78
					595	7.95
1989	Denmark	16+	M	123	109	14.3 (game)
1973	Norway	—	M/F	25,000	1,534	23 (male) 44 (female)
1981	United States	14–18	M/F	10,634	436	—
1987	Saudi Arabia	11–20	M	—	542	—
1980	Finland	10–58	M	—	1,989	—
			F	—	83	—
1985	Denmark	9–19	M/F	6,600	343	19
1980	United States	7–18	M/F	1,272	34	0.51 males 1.1 females
1990	Denmark	10–18	M	152	62	5.6

Table 2 EPIDEMIOLOGICAL STUDIES OF SOCCER

Reference	Study period	Population	Sample size	Design	Injury definition	Data collection	Epidemiologic critique
Albert	1979–1981 Outdoor and indoor seasons	NASL professional males	56	Cohort prospective	Only time loss injuries	Trainer	• Small number • No statistical analy • Reasonable injury definition • Dependable reporting system • Inadequate injury [illegible] for analysis
McMaster	1976–1977	ASL professional	15	Cohort prospective	Any injury reported	Trainer	• Small number • No statistical analy • All-inclusive injury definition • Dependable reporting system
Nilsson	1975, 1977 Two 5 day tournaments	International 11–18 year olds	25,000	Cohort prospective	Any injury reported	Trained attendants on field	• Male and female • Dependable reporting system • Large number • No statistical analy • All-inclusive injury definition • Brief, unusual study period • Skill bias
Sullivan	1979 Spring season	Oklahoma 7–18 year olds	1,272	Cohort prospective	Only time loss injuries	Coaches and parents	• Male and female • Large number • Unreliable data collection, diagnosis, severity • No statistical analysis • Reasonable injury definition
Ekstrand[10–14]	1980 Spring and fall seasons	Swedish senior male amateurs, avg age 25	180	Cohort prospective	Only time loss injuries	Per coach with subsequent exam by team physician	• Dependable reporting system • Moderate number • Appropriate statistical analysis • Reasonable injury definition • Skill bias as only the best players were studied
Ekstrand[9]	1980	Swedish senior male amateurs, avg age 25	180	Case control retrospective	Injuries requiring medical attention or more than 1 week time loss	Interview exam by physician, review of hospital records	• Confusing definition • Retrospective reporting system may be incomplete • Moderate number • Appropriate statistical analysis • Old injury data is contaminated with nonsoccer injuries • Skill bias

2.5.2. Injury Definition

The confounding factor in soccer injury epidemiology has continued to be the variety of methodologies used. The definition of injury has proved to be a significant problem, with certain authors choosing to define it as any injury reported, which can result in an over reporting of injury incidence, as in the series of McMaster and Walter (1978). In this study 46 (77%) of the 60 reported injuries reulted in no games being missed.

Ekstrand and Gillquist, (1983), Jörgensen (1984) and others subsequently have used the definition of injury as; an event occurring during a game or practice session, causing a player to miss the next game or practice session. This has been accepted as an appropriate convention and can be further broken down into mild, moderate or major injury depending on the amount of time lost from play. An excellent critical review by Keller, Noyes and Buncher (1987) assessed the epidemiological methodology used in six specific soccer injury studies. They re-emphasised the importance of injury definition and the confounding effects of age, sex, intensity of play and other factors, on the injury rate. Table 2 summarises the findings of Keller's review looking at four American studies (Albert 1983, McMaster 1978, Nielsen 1989, Sullivan 1980) and two Swedish studies, both carried out by Ekstrand *et al* (1982/1983). They were all cohort prospective studies, except for Ekstrand (1983) who performed a case control retrospective study on 180 senior amateur players. Albert (1983), Sullivan (1980) and Ekstrand (1980) used the time loss structure to define an injury and therefore a comparison between these two studies would be more relevant. The size of the respective samples however was very different, Albert's study included only 56 professional players was too small to be significant statistically and the injury analysis was described as inadequate. In contrast Sullivan (1979), co-ordinated a large prospective study with more than 1200 youth players, but used an unreliable form

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of data collection to assess the diagnosis. Ekstrand (1982) used a good definition of injury, with a moderate sample size which was assessed with appropriate statistics. Keller *et* al (1987) pointed out that Ekstrand's retrospective data may have been incomplete and that his results were contaminated with non soccer injuries.

2.5.3. Youth Soccer

A general conclusion which can be drawn from current epidemiological information is that the incidence of injury, while playing soccer, appears to increase with the age of the player. Studies of the Oklahoma and Norway Cups, confirmed roughly comparable injury rates for adolescents. However, Sullivan et al (1980) prospectively studied 1,272 youth players (under 19) and at least a five fold lower incidence of injury was found among 7 to 12 year olds, compared with the older youths. Nilsson and Roaas (1978) found a surprisingly high level of injury among adolescent soccer player, although every minor injury was included such as blisters and abrasions. Schmidt-Olsen *et al* (1991) carried out a prospective assessment of injuries in youth players over a one year period. Their study concluded that the injury incidence increased with player age, with 70% of the injuries affecting the lower extremity.

Another study by Nielsen and Yde (1989) assessed a relatively small group of males approximately, 100 adults and 30 boys aged between 16 and 18 years. A time loss structure was used to define injury and interestingly they found that 37% of all injuries were related to overuse. However, the main conclusion was that casual and recreational players were most frequently injured during tackling (44 to 48%), whereas 54% of soccer league injuries occurred during running. A worrying result from their study was that 28% of the injured players, still had injury problems after one years follow up.

Lohnes (1994) at the World Soccer Symposium on the Sports Medicine of Soccer, gave an excellent overview of youth soccer injuries in the United States. Six million children under the age of 12 participate in youth soccer in the United States and he referred to 15 epidemiological studies which included players under the age of 16, 7 of which examined youth exclusively. These studies were carried out in a variety of circumstances involving tournaments, casualty departments and clinic visits. The injury rate was found to be extremely variable between 1 and 20 injuries per 1,000 hours of exposure. He concluded that the incidence and severity of injury increased dramatically with age and that girls were more commonly injured than boys. The most common injuries were; contusions, ligament sprains and muscle strains. The lower limbs were affected in 75% of injuries although, goalkeepers were more exposed to upper limb injuries and fatal injuries were extremely rare. He broke down lower limb injuries in youth as follows: the thigh: 8-22%, knee: 10-20%, ankle: 10-30% and foot 5-15% (Lohnes, 1994).

Several specific youth injuries have been identified through epidemiological assessment which are worthy of mention. These are growth related injuries to the apophyses, stress injuries and avulsion fractures. Osteochondritis dissecans remains of uncertain aetiology and is commonly associated with sport. Spondylolisthesis should also be considered, especially in soccer players between the ages of 13 and 16 years, where it is likely to be related to stress fractures of the pars interarticularis.

2.5.4. Senior Soccer

The epidemiology of adult male soccer injuries has been pieced together from various quite distinct and inherently biased sources. The Accident and Emergency Department is a valuable source of sports injury epidemiology, however, by its very nature it tends to be biased towards traumatic injury, as opposed to overuse injuries and is dependant on the social composition of the catchment area. For example, during this current study I undertook a parallel study between July and October of 1993, to assess all sports injuries presenting to the A & E Department of an Associate Teaching Hospital and identified those injuries subsequently requiring orthopaedic referral. (MacKay *et al.* in press). During this period of observation 480 patients with sports injuries presented to the Accident and Emergency Department representing 6% of all attendances. One in four sports injuries (117) required further orthopaedic referral. Soccer accounted for 64% of all sports related injuries and 78% of this group required further orthopaedic referral. Interestingly over 90% of these sports injuries were self referrals although four came via their GP and seven directly from school. Similar results have been reported by Walters *et al* (1984) and Compton and Tubbs (1977), although neither author assessed the need for orthopaedic referral. The bias inherent in emergency room reporting is evident in the study by Hoy *et al* (1992). He studied soccer injuries presenting to a Danish Emergency Room over a period of a year and reported that 86% of players were injured during a match while only 9% involved insufficient warm up and 5% occurred during training. The most common mechanism of injury was contact. This is quite distinct from field studies which have consistently reported higher incidences of non contact injuries.

Insurance Reporting

Insurance reporting has been used by several authors such as Berger and Vachon (1986). This study involved a very large group, which is possible through insurance analysis (The Insurance Company of the French Rhone-Alpes Soccer Association). A total of 6,153 accidents from 123,175 registered amateur players were recorded for the season 1980-81. This was extrapolated to estimate the number of matches and practice games undertaken and came up with an injury risk estimate. Interestingly fractures represented 16.6% of injuries and were the most common injury in players under 14 years of age. The cost for France over one year was estimated at $20,000 000 and the total number of sick leave days at 2000 years.

These findings would be in keeping with the results reported by Eriksson, (1994) from the Karolinska Institute in Sweden. He reported on the spiralling costs of sports injury management, in particular the number of permanent disability claims made to the Comprehensive Swedish Insurance Company, Folksam. This compulsary insurance body for sportsmen reported that between 1980 and 1983, about 2,000 soccer injuries per year were reported. In 1990 no less than 5,700 were reported, although the number of soccer players had decreased. There was a steep increase in the number of permanent disabilities arising from competitive football. Socio-economic factors may have contributed to this rapid increase. It was evident from the Insurance Company's perspective that ACL injury proved to be the most important factor contributing significantly to the spiralling costs. (Eriksson 1994,).

Ekstrand during 1982 and 1983 published several papers relating to all aspects of soccer injury epidemiology including their mechanism and prevention. He carried out well controlled prospective studies using a dependable reporting system, a reasonable definition of injury, and good statistical analysis, but in addition carried out a retrospective study. Technically this retrospective study was not as well designed with several reporting errors. In addition to this base line work he undertook field studies to address aspects of the warm up, and cooling down routines, as well as training load. He went on to assess playing surfaces and equipment, then actively introduced changes under medical supervision in a controlled fashion and analysed the outcome. Due to the comprehensive nature of his work despite the numerous studies carried out since, his work remains topical. Ekstrand and Gillquist in their initial study chose to use the time loss definition of injury as subsequently recommended by Keller *et al* in 1987. In Ekstrand and Gillquist's (1983c) Swedish study 180 players were examined prior to the season commencing. They subsequently identified 256 injuries sustained by 124 players and worked out a yearly incidence per player of 0.88 for a minor injury, 0.38 for a moderate injury and 0.16 for a major injury. Eighty eight percent of injuries were localised to the lower extremity. Of these, 69% (177) were the result of trauma and 31% (79) were due to overuse. Sprains accounted for 29% of all injuries and 59% involved the ankle and 34% the knee. Strains accounted for 18% of recorded injuries 80% of which involved the lower limb. Fifty one knee injuries were seen, 35 (69%) were caused by trauma and 16 (31%) through overuse. He found that two thirds of traumatic injuries occurred in games and 59% occurred during contact with another player. In contrast 31% of injuries were related to overuse the majority of which occurred during practice (Ekblom, 1994).

Albert in 1983 compared the effect of indoor and outdoor soccer on professional players. He found that the exposure rates were similar, but the incidence of injury was twice as high in outdoor soccer (1.45 injuries per player) as in indoor soccer (0.8 injuries per player). Outdoor soccer also accounted for 75% of all major injuries. Interestingly the indoor soccer appeared to be associated with more frequent upper limb injuries, dental injury and tendinitis. (Keller *et al*, 1987).

Despite the differing demands of player position it is interesting that Ekstrand and Gillquist (1983) and McMaster and Walters (1978) found no difference in injury rates according to position. Other authors such, as Sullivan, Gross and Granna (1980) confirmed some variation with goalkeepers highly represented, with midfield players experiencing the lowest incidence of injury. Sullivan's study addressed adolescent players and involved a large sample group.

General Conclusions

The Swedish study by Ekstrand and Gillquist identified several significant factors which they considered contributed to soccer injuries. They assessed muscle strength and imbalance in the lower limbs and concluded that residual weakness from previous injury and joint laxity predisposes to reinjury. They also concluded that 20% of minor injuries in senior Swedish soccer players were followed within 2 months by moderate or major injury to the same player. (Ekstrand and Gillquist, 1983b). Field conditions were judged to contribute to at least 75% of the reported soccer injuries and interestingly, 30% of traumatic injuries were thought to be related to foul play as assessed by coaches and referees. They concluded that although the risk of soccer injury is low it is highest among older athletes. Reduced muscle flexibility was reported in 67% of players (n = 86) except for hip flexion for which soccer players appear to be more flexible. He concluded that players with tight muscles showed a higher though not significant incidence of muscular strains. (Ekstrand and Gillquist, 1982-83d).

2.5.5. Female Soccer

The most significant difference in injury pattern between the male and the female game was revealed by the NCAA statistics. The incidence of ACL injuries among female soccer players was twice as high as that occurring in men. This finding has also been noted in other pivotal sports, such as basketball. The explanation for this as yet remains unclear. Engström *et al* (1991) studied soccer injuries among elite female players in Sweden and noted an overall incidence of injury more than twice of that for men (12 per thousand playing hours, compared to 5 per thousand playing hours for men). Although this was a relatively small study with only 41 female players included he postulated that the injury differences may well be related to the fact that the mean training time for the average elite female player was approximately half of that of her male equivalent. Brynhildsen et al (1990), in contrast retrospectively assessed 150 female senior soccer players and found a similar injury rate of 0.18 injuries /player/year as had been reported for males. They also found fewer serious knee injuries amongst the females ,although, they were unable to identify players who may have given the sport up after serious injury.

It has also been postulated that the injury rate in female players may increase during pre-menstrual and menstrual periods (Moller-Nielsen and Hammer, 1989). They attributed the high incidence of soccer injuries to physiological and psychological symptoms that occur during the pre-menstrual time such as increased irritability and general discomfort. They also found that women on the pill had a lower rate of traumatic injury ($P<0.05$).

CHAPTER 3. MATERIALS AND METHODS

During an average season Professional Football teams are frequently decimated by sports related injuries. These perennial injury problems may compromise individual player aspirations, club performance and undermine the quality of national teams. Yet, there has not been a comprehensive study into the pattern of sports injuries in the modern professional or amateur game in Britain. This study was planned to provide information which is essential to address the less than satisfactory status quo.

3.1 Aims of the Study

The aim of the study was to assess soccer injuries arising in Scottish professional football over a period of one year, subject to normal medical ethics and confidentiality.

Aims (a) to establish the frequency of injury.in soccer.

(b) to identify the mechanism of injury in particular whether contact or non-contact.

(c) to describe the injury pathology and the tissues involved.

(d) to establish the anatomical regions most frequently affected.

(e) to identify any associations between injury and player position, level of competition or age.

(f) to address the problem of injury recurrence.

(g) to make a broad assessment of the needs for sports related orthopaedic provision.

PERFECTLY PLAYABLE

VARIABLE PLAYING CONDITIONS

It was clear that such a study would provide a unique insight into injury risk and its consequences for professional players. This foundation would provide a platform for educated debate on injury prevention, as well as highlighting areas which would require further research. Although it is recognised that the study could not conclusively determine whether a reduction in the number of league fixtures would reduce the injury frequency, or whether a winter break would be beneficial, it was hoped that informed comments on these important topics could be made.

3.2. Players

To be as comprehensive as possible, thirty eight professional and semi-professional Clubs associated with The Scottish Football Association were contacted. Clubs from the four Senior Leagues were invited to participate. Viz., the Premier Division, the First Division, the Second Division and the Third. Records kept by The Scottish Football Association of Club Doctors and Physiotherapists were used to establish contact.

Eighteen players normally constitute a first team pool, therefore 18 players were identified from each participating team. It was recognised that if Club cooperation was to be obtained and subsequently maintained, confidentiality, with regard to injury data, was essential. Within the commercial world of football, a significant injury history can seriously undermine the value of a talented player.

All players were senior players currently involved in professional soccer and no selection criteria was applied with regard to age or previous injuries. The final study population at the beginning of preseason totalled 480 professional players. This was considered adequate for a comprehensive and meaningful prospective study.

3.3. Doctors and Physiotherapists

Preliminary Discussion

All doctors and physiotherapists registered with The Scottish Football Association were contacted in writing, detailing the proposed study protocol. Feedback was encouraged and a response sheet was provided through which the individuals could acknowledge their support or otherwise. This correspondence was backed up by personal contact, to reinforce the purpose and importance of this study as well as to address individual concerns. It was clear from the preliminary discussions that the respective medical teams would have to liaise with the Club Chairman and Directors, as well as the management team, before committing themselves. Several concerns were clearly voiced which related to the amount of work involved in undertaking such a study, how it would directly benefit individual Clubs and concerns regarding confidentiality were again raised.

Explanation

It was explained that this sports injuries study was long overdue and would ultimately be for the benefit of all participating clubs. Clubs were reassured that their individual injury patterns would not be reported in isolation and therefore no direct assessment could be made of their training techniques, injury rates or medical support. It was agreed at this point that the results should be dealt with collectively and with this position accepted, there was a general concensus that this ambitious study would be worthwhile.

Interestingly, each doctor and physiotherapist had their own explanation for the current high level of injury. Opinions ranged from; the frequency of games, the training patterns used and the number of matches played, as well as the occasionally hostile weather conditions. It was agreed that a major prospective study would provide a base line for discussion and promote a foundation for future research.

Individual clubs would receive direct feedback, and a clinical meeting, sponsored by The Scottish Football Association, would provide an opportunity to discuss the results of the study. A commitment was given to produce a preliminary and subsequently a final written report with recommendations relating to injury prevention, subsequent management and rehabilitation.

Workload

To provide potential participants with some idea of the work involved with such an undertaking, a pilot project was structured which detailed the overall objectives of the study, the form of data collection proposed and how the data would be collated and subsequently analysed. It was explained, that I personally would contact them on a weekly basis over a full playing year and that the data collection process would be simplified as far as possible. I would prepare the data sheets, distribute them with stamped addressed envelopes for their return and discuss any ambiguities with participants.

3.4. Pilot Study

The initial pilot study was a rather ambitious undertaking. Comprehensive clinical details were sought of the type of injury, site of injury, treatment, rehabilitation, and whether a hospital referral was required,. This was to be detailed on a data report form for each injury, with clearly defined criteria for injury qualification. Injury was defined on a time loss basis, as recommended by Ekstrand and Gillquist (1982) and Keller *et al*, (1987). It was also hoped that data regarding player weight and level of activity could be collected on a weekly basis for all 18 players in each club, whether fit or unfit, and this pilot study was tested. The participating club doctors and physiotherapists felt that their enthusiasm was unlikely to be maintained and given the normal course of events this would seriously undermine the quality of the study and even its viability.

The study protocol was redesigned in an attempt to maximise cooperation, to ensure valid and meaningful data collection and to minimise unnecessary workload.

3.5. Objectives

3.5.1. Duration of Study

Epidemiology is the study of how often and why disease occurs within a defined group. Epidemiological information can then be used to plan and evaluate strategies to prevent illness and to guide the management of patients in whom disease has already developed. Within the context of soccer, a longitudinal prospective study should be for the duration of a complete season (in this case season 1993-94). A longitudinal approach had been undertaken to assess soccer injury epidemiology in the United States, Sweden and Denmark; however, such an undertaking had not been successfully completed for the British game. In addition to the detailed analysis of the full season 1993-94, the preseason period was also studied.

Players are exposed to injury through competition and training. It was evident from the literature on the epidemiology of injury in soccer (from authors such as Ekstrand and Gillquist 1982, Sullivan 1980, and Ekblom, 1994) that this intensive preseason period of training, which normally lasts between four to six weeks, could have a very important role in both aetiology and potential prevention of soccer injury. This had not previously been studied.

The final study design was approved by The Scottish Football Association Medical Subcommittee and players were studied during the preseason period and subsequently on a weekly basis for the rest of Season 1993-94.

3.5.2. Sample Size

To draw accurate epidemiological conclusions, it is important to target, as far as possible, the entire population at risk. By attempting to involve all professional and semi-professional players from the four top Scottish Leagues, it would be possible to assess not only those injured, but also uninjured players. It would therefore be possible to draw appropriate at-risk conclusions, without applying logical error in the form of a floating numerator.

A small sample size could be unrepresentative, producing results which may have arisen by chance. The scope of these errors can be quantified statistically. In this study target population was in effect the study population. This eliminates some of the systematic sampling errors associated with randomisation, which could have arisen if a less positive response had been obtained from the target population. The study population was simply characterised by professional players from professional and semi-professional clubs affiliated with The Scottish Football Association. It was recognised that since the first team pool of 18 players were selected for anonymous representation within the study, a skills bias is introduced; however, since our target population is the professional footballer this would have been expected. Epidemiology thrives on heterogeneity, and no age limit was applied and no account was taken of a previous significant injury when selecting players.

It is hoped that the results from this major epidemiological study will benefit soccer players at all levels of the game. It is appreciated that the skills bias noted above may indeed be classed as a systematic sampling error and therefore further extrapolation of the results to the soccer population, in its most general terms, would remain a matter of judgement.

3.6. Final Study Design

Recommendations were adopted from the Research Committee of the American Orthopaedic Society for Sports Medicine which undertook the task of developing valid methodologies to analyse sports injuries. The importance of research design, the definition of terms such as "injury" and the study population itself was recognised

A prospective study was chosen using questionnaires administered at an interview, after clinical examination. A representative sample of adequate size was obtained involving 480 players. Several specific objectives were defined before structuring the questionnaire. It was appropriate to use a language which was both clear and simple, that would be understood unambiguously by all participating medical personnel. Questions were structured to be to the point to extract the maximum amount of valid information in the minimum amount of time.

The questionnaires addressed several key points. The player's coded number was always specified on the injury report form and from this additional information, the player's height, weight, playing position etc. could be associated with the injury report. The questionnaire detailed the time of reporting and whether the player was still unfit. A record of the players' activities during that week, with regard to competitive matches and training sessions was made. It was important to establish whether the injury was sustained during a match, and if so, whether the player completed that game. For coding purposes the anatomical regions of the body were broken down into broad categories, such as the thigh or knee. The mechanism of injury was sought and classified into contact or non-contact. Contact injuries were broken down into kicks, tackles and collisions which would be terminology clearly understood by the player and interpreted appropriately by the clinical staff.

It was recognised that injury recurrence could represent a confounding variable, therefore if an injury was recurrent, this was specified. It was also important to establish whether hospital treatment was required. When a hospital visit was necessary, a record was kept if the player was detained overnight (which was thought to broadly relate to the severity of injury) and whether surgery was required.

Method

The questionnaire design enabled a qualitative judgement to be made on the type of injury and its duration, thus avoiding some of the complications associated with quantitative measurement.

All participating doctors and physiotherapists were contacted detailing the final study design. The importance of maintaining the discipline of accurate weekly returns was emphasised, and the fact that this would be only possible if the study proposal was greeted with some enthusiasm was acknowledged. This turned out to be the case and all the doctors and physiotherapists who eventually participated in the study were extremely supportive and gave up a lot of their time to ensure accurate and valid data collection. They also frequently liaised with me when difficulties arose.

Questionnaire Design

The data collection was divided into three clear phases with a separate questionnaire for each (see appendix). Form A was designed to specifically assess the general fitness of the individual players and therefore establish a baseline. Retrospective questions were made which would be used at the end of the season, to assess whether previous injury or surgery had an association with subsequent injury. Form B, in contrast, was an overall assessment to establish whether the players who had entered the preseason four to six weeks earlier were still fit and if not why? Injuries which may have arisen during preseason and had been adequately treated, were also reported. Essential to this phase of data collection was an assessment of the workload involved during the preseason. The number of training sessions and competitive matches undertaken were recorded. The converse of this analysis was that it highlighted essential training and preparatory matches which were missed through injury, which may have undermined the preseason preparation of certain players.

Form C represented the main data sheet. This provided core information relating to specific injuries on a week-to-week basis as the season unfolded. During the first three months of the season, any player who had been injured during the preseason period was assessed to identify any further recurrence of injury or any secondary injuries.

3.7. Validity and Quality of Data

Some of the issues relating to data quality and validity have already been addressed, such as the importance of clearly defined injury categories which can be interpreted and reported consistently by trained medical staff. The biggest concern with any sports injuries study is clearly defining the term "injury". The data produced relating to the risk of injury, is only as meaningful as the injury definition used. An awareness of the different definitions of injury is important for interpreting and comparing results. Albert (1983), Sullivan et al (1980) and Ekstrand and Gillquist (1982) recorded only injuries which resulted in time lost from play or practice and therefore directs attention to those injuries which are most likely to have an important effect on the athlete's health and performance. This was the definition chosen for this study and explained in detail to participating doctors and physiotherapists. The validity of time loss methodology can be assessed by looking at specific defined criteria. The coding and classification structure used for the injury report questionnaires may result in a slight degree of systematic error, although the time loss criteria provides a good balance between sensitivity and specificity for analysis.

Ideally, it would have been helpful to clearly define the duration of each injury, however, this complicated the input from the various medical teams and proved unworkable. However it was possible to assess the severity of injury by approximating the number of reports returned on consecutive weeks with the same injury described. For long term injuries, individual club doctors and physiotherapists notified me that the player was unlikely to return to competition during the season. Errors may have been introduced if players subsequently returned to competition without the club doctor or physiotherapist indicating so.

Soccer Injury Rates

The ability to establish a soccer injury rate, such as that used by McMasters and Walters (1978), facilitates epidemiological comparison as long as standardised techniques are used. In the above study, they were able to demonstrate an increased injury rate between youth and professional leagues, and described the number of injuries per hour exposed. This is a broad and an appropriate assessment of injury rate, but does not necessarily relate to the amount of training or level of competition. Therefore in a broad sense it is inappropriate, because it does not reflect the rigours of an average season, at whatever level of competition.

Injury Risk

Certain factors which may contribute to the injury risk were not considered suitable for inclusion in this study, such as the effect of foul play. This would have required an independent match report from the participating referees, relating to all injured individuals. This was not possible because for the purpose of this study players were anonymous and had been assured that their injury details would be kept confidential. A further risk factor which had been reported in previous studies, was the influence of the playing surface itself. Ekstrand and Gillquist (1982) identified poor field conditions as a contributory factor to soccer injury in about 25% of cases in Sweden. It was initially hoped that by liaising with the Meteorological Office, a climatic map could have been drawn for the various Scottish locations, to assess the effect of weather on playing conditions.. After preliminary discussions it was apparent that geographically the climatic variations would be extremely marked and difficult to relate to individual clubs and in particular individual players and their associated injuries. The Meteorological Office explained that soil samples from each pitch would be essential, as well an independent weather report from an individual at each match. Such a field study was not feasible, although the results from such a study would be of interest. The light-hearted illustration following page 85 highlights the importance of playing conditions in the Scottish game.

Repeatability

Repeatability is always an issue, especially when there is no satisfactory standard against which the validity of measurement can be assessed. No specific study was undertaken to assess the repeatability of the observations made by the physiotherapists and doctors involved in this study. There would have been concerns regarding confidentiality and the doctors and physiotherapists themselves may have felt as if they were being assessed, instead of the repeatability of their observations. The time loss injury definition certainly helped to remove some inter-observer variation, which may be a very subtle error relating to an individual's interpretation of what is normal and what is abnormal. Inter-observer variation may have existed as medical staff of varying levels of experience and expertise may well provide the stimulus for further research. In summary, it is hoped that the overall analysis of the sports injury data will provide an honest evaluation. To facilitate this most of the data will be presented in diagrams or charts. It is appreciated that excessive analysis, especially statistically, may result in concealment or confusion.

This is essentially an observational study which has been designed to observe the existing situation, in an attempt to understand the aetiology of injury. Studying players participating in the professional world of sport, can be extremely difficult and it is often impossible to draw an unequivocal conclusion.

Regression is the method of estimating the numerical relationship between variables. After detailed discussion it was felt that regression analysis in this situation, was unnecessary. Where appropriate Chi-squared tests were performed for the comparisons of certains groups. For the analysis of the subgroup of player's requiring surgery the Fisher's exact test was used because of the small proportions involved.

APPENDIX

Football Injuries Study Data Entry Form

Start of Season Assessment (Form A)

Player Number [ ] Age [ ] Height [ ] Weight [ ]

Position [ ] Fit [ ] Unfit [ ]

A. Is Injury Sports Related ? Yes [ ] No [ ]

If Yes, indicate area affected (tick)

Head [ ] Elbow [ ] Shoulder [ ] Back [ ] Thigh [ ]

Knee [ ] Ankle [ ] Groin [ ] Other, Please State : [ ]

Cause of Injury : Kick [ ] Tackle [ ] Collision [ ] Non-Contact [ ]

B. Any injury over the previous season resulting in more than 6 weeks out of the team ?

Yes [ ] No [ ]

If Yes, indicate area affected (tick)

Head [ ] Elbow [ ] Shoulder [ ] Back [ ] Thigh [ ]

Knee [ ] Ankle [ ] Groin [ ] Other, Please State : [ ]

Cause of Injury : Kick [ ] Tackle [ ] Collision [ ] Non-Contact [ ]

C. Did this Injury require Surgery ?

Yes [ ] No [ ]

If Yes, indicate area affected (tick)

Head [ ] Elbow [ ] Shoulder [ ] Back [ ] Thigh [ ]

Knee [ ] Ankle [ ] Groin [ ] Other, Please State : [ ]

If more than one operation please state number, e.g. Knee [2]

Has player ever required Knee Surgery ? Yes [ ] No [ ]

If yes, please give brief details

[ ]

Football Injuries Study Data Entry Form

End of Pre-Season Assessment (Form B)

Player Number [ ] Date [ ]

Fitness :- Fit [ ] Unfit [ ] Weight [ ]

	Week 1.	Week 2.	Week 3.	Week 4.	Week 5.	Week 6.
Training Sessions :-						
Matches played :-						

If injured , please give date of injury :- [ ]

A. If injured, is this a recurrent problem ? Yes [ ] No [ ]

Sport related [ ] Non-Sport Related [ ]

B. Was injury sustained during a match ? Yes [ ] No [ ]

If Yes, did player complete match ? Yes [ ] No [ ]

Head [ ] Elbow [ ] Shoulder [ ] Back [ ] Thigh [ ]

Knee [ ] Ankle [ ] Groin [ ] Other, Please State : [ ]

Cause of Injury : Kick [ ] Tackle [ ] Collision [ ] Non-Contact [ ]

C. Did the player require hospital treatment ? Yes [ ] No [ ]

If Yes, was the player detained overnight ? Yes [ ] No [ ]

Was Surgery required ? Yes [ ] No [ ]

If Yes, indicate area affected (tick)

Head [ ] Elbow [ ] Shoulder [ ] Back [ ] Thigh [ ]

Knee [ ] Ankle [ ] Groin [ ] Other, Please State : [ ]

If more than one operation please state number, e.g. Knee [2]

D. If the injury was to the HEAD ;

Was there a Loss of Consciousness ? Yes [ ] No [ ] Duration [ ]

Memory Loss ? Yes [ ] No [ ] Duration [ ]

Football Injuries Study Data Entry Form

Weekly Player Assessment (Form C)

Player Number ☐ Date ☐

Fitness:- Fit ☐ Unfit ☐ Weight ☐

Number of Training Sessions:- ☐

Number of Matches Played:- 1st ☐ Reserve ☐ Other ☐

A. If injured, is this a recurrent problem ? Yes ☐ No ☐

Sport related ☐ Non-Sport related ☐

B. Was injury sustained during a match ? Yes ☐ No ☐

If Yes, did the player complete match ? Yes ☐ No ☐

Head ☐ Elbow ☐ Shoulder ☐ Back ☐ Thigh ☐

Knee ☐ Ankle ☐ Groin ☐ Other, Please State : ☐

Cause of Injury : Kick ☐ Tackle ☐ Collision ☐ Non-contact ☐

C. Did the player require hospital treatment ? Yes ☐ No ☐

If Yes, was the player detained overnight ? Yes ☐ No ☐

Was Surgery required ? Yes ☐ No ☐

If Yes, indicate area affected (tick)

Head ☐ Elbow ☐ Shoulder ☐ Back ☐ Thigh ☐

Knee ☐ Ankle ☐ Groin ☐ Other Please State :

If more than one operation please state number, e.g. Knee 2 ☐

D If the injury was to the HEAD ;

Was there a loss of Consciousness ? Yes ☐ No ☐ Duration ☐

Memory Loss ? Yes ☐ No ☐ Duration ☐

This form is continued on the other side, please turn over.

If more than one significant injury, please complete two forms

Football Injuries Study Data Entry Form

Weekly Player Assessment (Form C) Cont.

E. Type of Injury sustained. Please complete as accurately as possible.

Bone :	Fracture	☐	Dislocated	☐	Stress Injury	☐
Muscle :	Sprain	☐	Torn	☐	Haematoma	☐
Soft Tissue :	Bruised	☐	Skin Broken	☐		
Ligament :	Sprain	☐	Torn	☐		
Tendon :	Torn	☐	Tendonitis	☐		

F. Is the injured area infected ? Yes ☐ No ☐

G. Do you expect the player to be able to return to full training within 3 days ?

Yes ☐ No ☐

This information is subject to the usual ETHICS concerning Medical Confidentiality. If you have any problems filling in these forms, please refer to the examples enclosed.

4 Results

4.0 Results - Retrospective Assessment

Introduction

Oolaf Lindahl stated that "soccer is not a sport it is a disease of the knee". Although this may have appeared as a cynical remark, it does effectively focus the soccer community's attention on the knee. This chapter analyses all knee operations previously performed on the soccer players entered in this study.

This retrospective assessment was unable to identify injured players who were unable to resume competitive soccer. Subject recollection bias was also a confounding factor but it was still felt that this retrospective study would provide a crucial insight into the surgical histories of the players.

4.2 Knee Surgery

Seventeen percent(78) of the 462 players studied had previously required knee surgery (Figure 4.1). The operations performed upon each of the 78 players are illustrated (Figure 4.2). As might be expected, meniscal injury was the commonest surgical diagnosis, and 44 players required a partial meniscectomy. The medial meniscus was three times more frequently affected than the lateral meniscus.

Considering the contact nature of the sport it is interesting that only one player had sustained a patella fracture and there were only two cases of osteochondritis dessicans reported.

4.2.1. Cruciate Injury

A subgroup of 8 players had required reconstructive surgery for rupture of the anterior cruciate ligament. The relatively small size of this group makes further analysis less significant. From the analysis of this subgroup there appears to be a significant skills bias, with more players in the Premier and First Division having undergone reconstructive procedures. This has to be qualified by the fact that twice as many teams from the Premier and First Division (19) were studied compared with the Second and lower divisions (8). Half of the players who required ACL reconstruction had an isolated tear; however, the other half had various combinations, the most common being a medial collateral ligament disruption and an ACL injury and in one case the posterior cruciate ligament was also ruptured (Figure 4.3).

4.2.2. Player Position

The players that required knee surgery were broken down according to their playing position, as illustrated (Figure 4.4). It is clear that defenders and goal keepers are excessively represented (Chi-squared=14.735, df=3, p=0.002). There was no strong evidence that the proportion having previous surgery differed significantly for defenders and goal keepers. Similarly, there was no strong evidence that the proportion having previous surgery differed significantly between midfield players and forwards.

4.3 Discussion

Interestingly, only 17% (78) of the 462 players studied had previously required knee surgery. This is a surprisingly small percentage considering that from previous soccer injury epidemiology, it would be estimated that at least 20% of soccer injuries would involve the knee and on average each player would sustain one to two significant injuries per season. The cumulative effect of this exposure rate on players whose average age was mid to late twenties (26yrs), would suggest that if this injury rate is representative of the knee injuries in British football, then a significant percentage of players may give up football after surgery or are unable to return to the same level of competition.

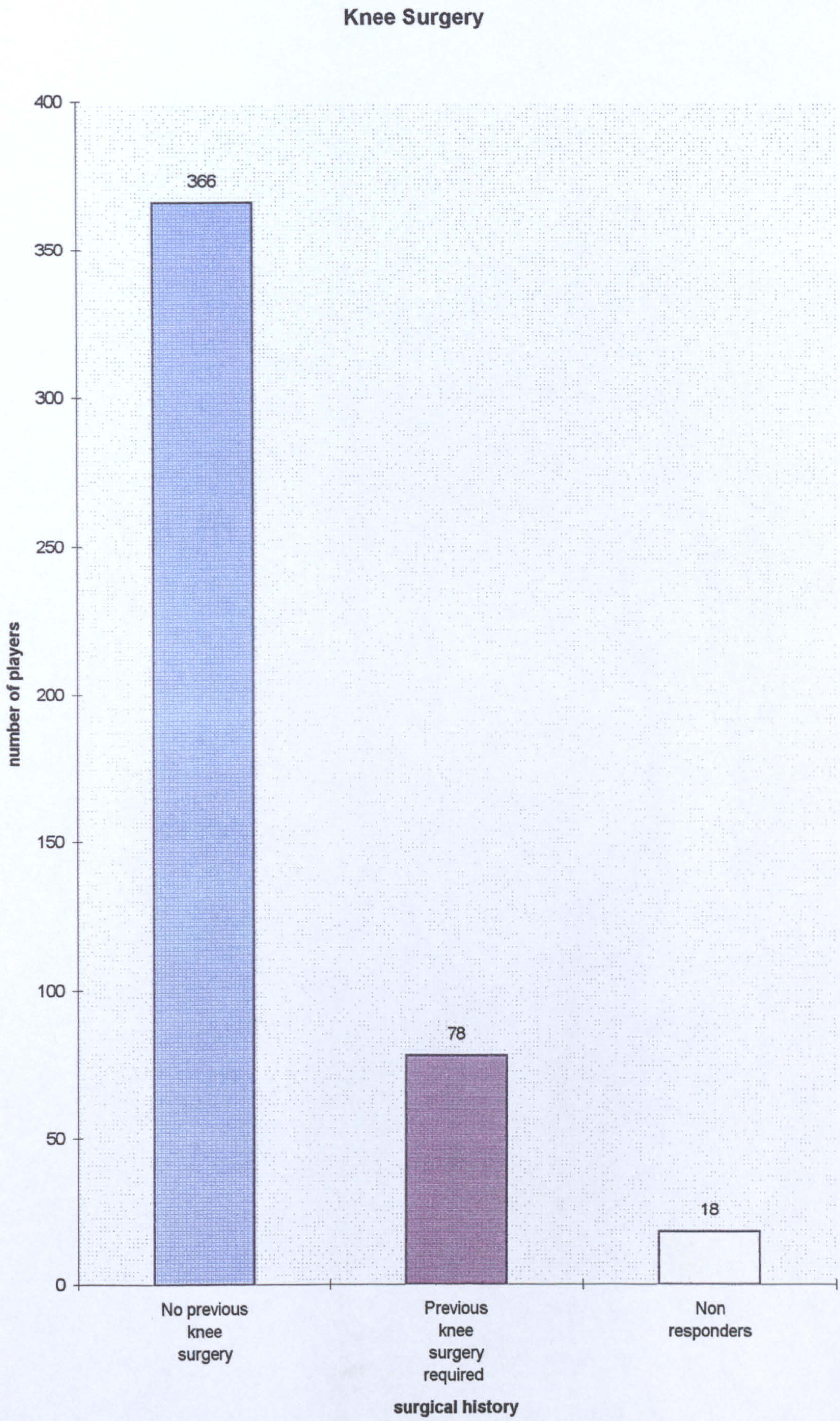
Aglietti in 1994 at the US Symposium on the Sports Medicine of Soccer presented an overview of the disability which results from knee injury in sport, in particular ACL disruption, which is a research field in which he has been extremely active. He pointed out that few soccer players were able to return to competition after ACL injury without surgery. He quoted from his own work in 1988 when he followed 36 competitive soccer players with ACL deficient knees for an average of 3.5 years after arthroscopic partial meniscectomy. Eleven (31%) of the 36 were able to return to the same competitive level, 7 (19%) dropped to a recreational level, 9 (25%) had to change to a less demanding sport and the last 9 (25%) were unable to participate in any sport. This finding may in part explain the small percentage (2%) of players in this study who are still playing at the highest level after knee ligament reconstruction. Another relevant point is that there may be a small percentage of players who have sustained or repeatedly sustained knee sprains who may well have an ACL injury, but have not yet been considered for surgery. Engström (1990) studied 64 players for one year, 11 knees required surgery, 7 for ruptured ACLs of which 3 were regarded as chronic. Engström continued to follow these players for between 9 and 18½ months after their injury and only 4 of the 12 players with major knee injuries returned to play at their pre-injury level. The others had been transferred to lower divisions or were still in rehabilitation.

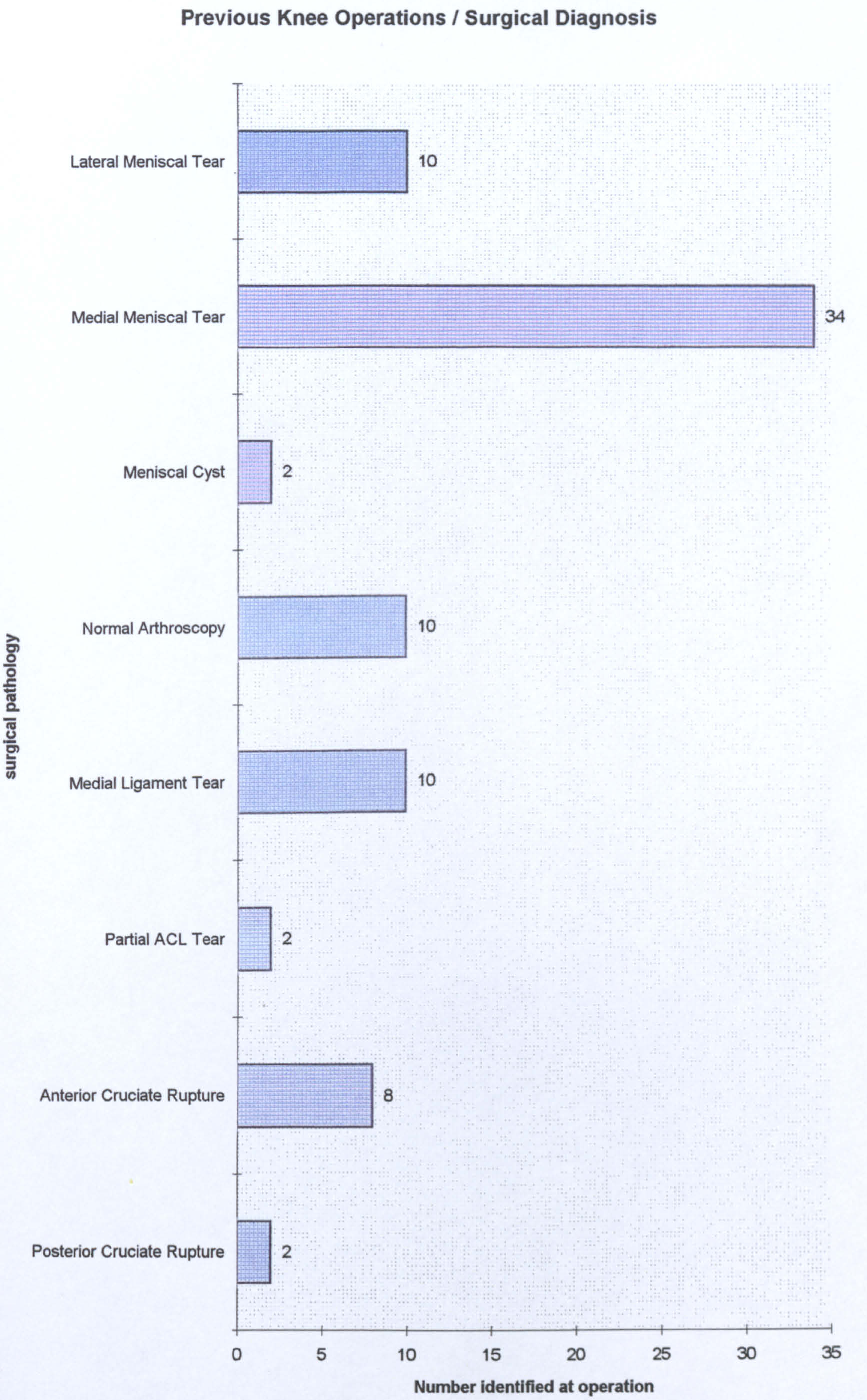
Only two percent (8)of the players in this study had required ACL reconstruction, however, 9.5 percent (44) had required partial menisectomy. This figure may conceal a small percentage who had an ACL deficiency but were not offered a reconstructive procedure. Neyret *et al* (1993) assessed the impact of ACL deficiency on soccer players after partial meniscectomy. He divided 77 soccer players (studied retrospectively) into two groups; group 1 were found to have intact ACL and group 2 which at the time of surgery were ACL deficient. On extended follow up it was apparent that only 5% of group 1 required further meniscectomy, however, 32% of group 2 required a repeat procedure and 16% of this group subsequently required operations for osteoarthritis, as opposed to only 2% of group 1. The conclusion of Neyret's work is that ACL rupture and meniscal tear in a soccer player is an indication for a surgeon to consider a reconstructive procedure. If they are unwilling to undergo surgery then the patient should be advised to decrease their level of activity and they should be counselled regarding the high risk of injury associated with further competitive play.

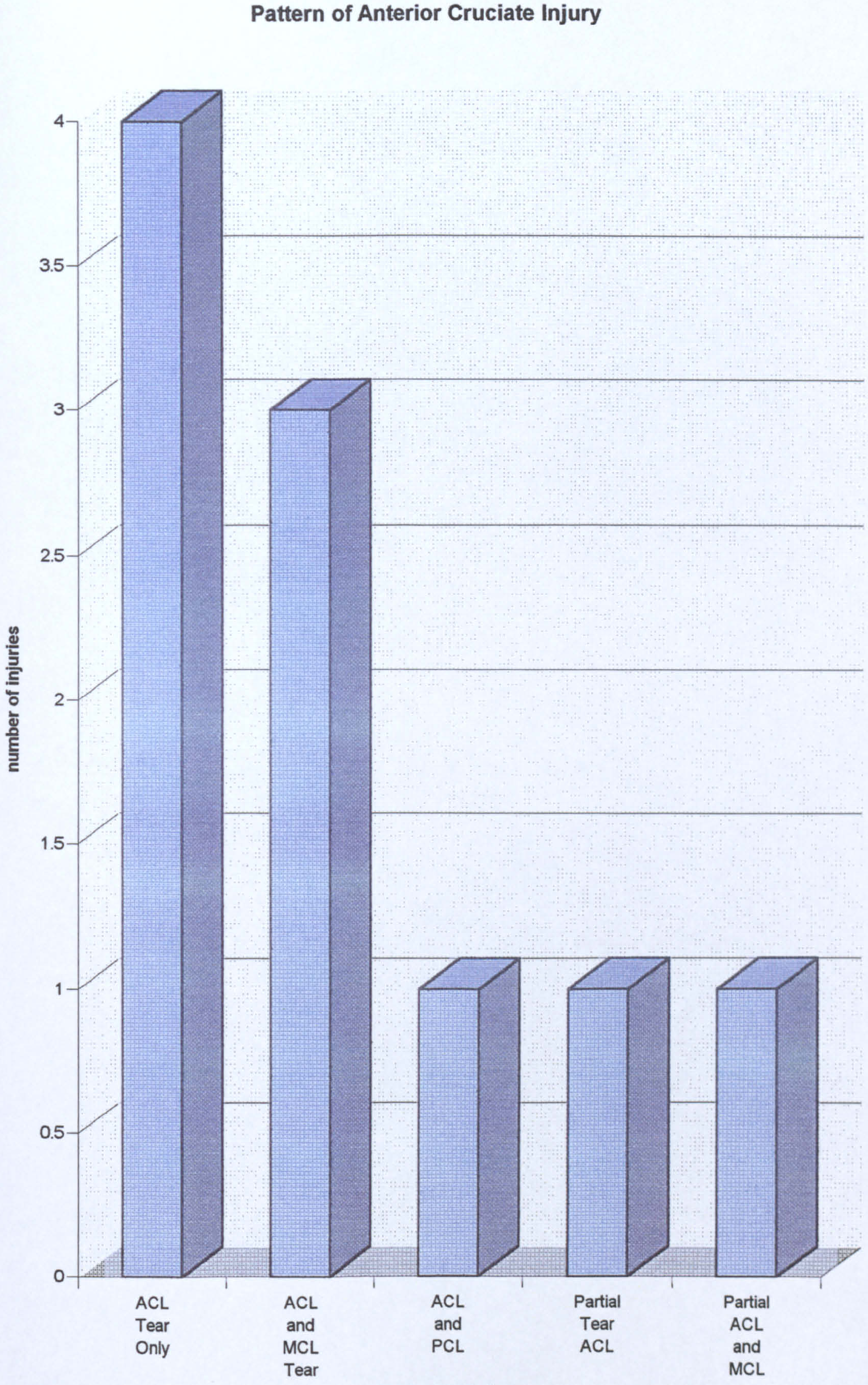
Only one player had a meniscal repair which may be slightly misleading in that several players may have undergone this procedure but did not make a successful return to competitive football. This however remains unlikely since a partial meniscectomy could be performed if the initial repair was unsuccessful. Since it is accepted from scientific literature that a meniscectomy may be used to provide an animal model for osteoarthritis (Allen *et al*, 1984), meniscal repair should be considered more frequently in appropriate cases, in particular in younger players with a clear peripheral detachment. In such cases the results of peripheral meniscal repair have been promising, although the crucial period of rehabilitation is clearly prolonged (Dehaven 1990).

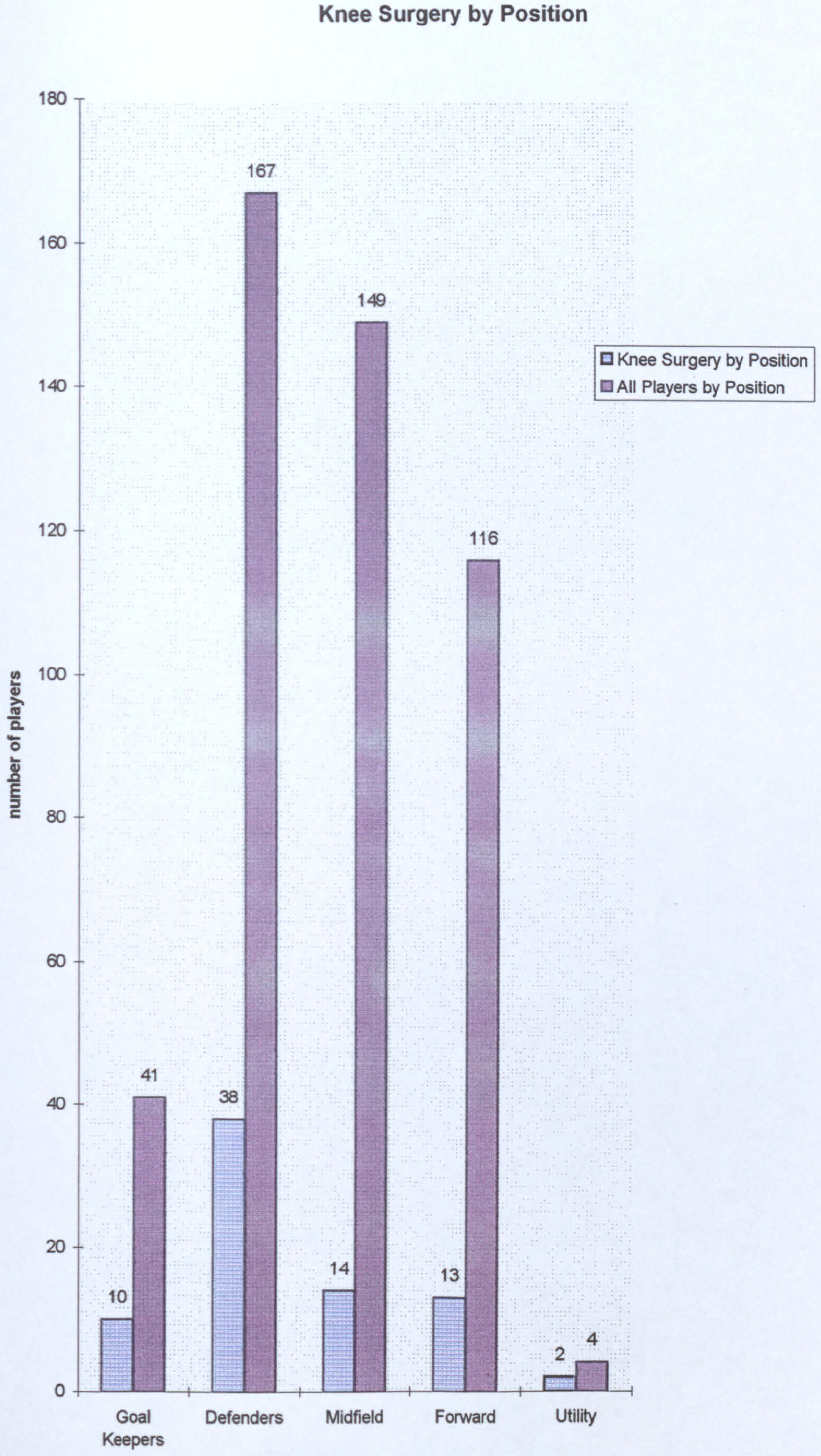
The prominence of defenders in this retrospective study may reflect the fact that defenders often compromise the mechanical strength of their knee joints when tackling. The biomechanics of a defender extending a leg to block a player who is accelerating past him, can result in enormous forces being transmitted across the defender's knee joint. Sullivan *et al* in 1980 also found some variation in injury rates according to player positions, with midfield players experiencing the fewest and Latella et al (1992) found senior forwards to be most at risk. In contrast, Ekstrand and Gillquist (1983) and McMasters and Walters (1978), as well as Engström (1990) identified no positional effect on the overall injury rate within a team.

Although a retrospective study of this kind does have its limitations, it does provide a unique insight into the surgical history of the professional footballer and is therefore worthy of inclusion.


Knee Surgery
400
350
300
250
200
150
100
50
0
number of players
366
78
18
No previous knee surgery
Previous knee surgery required
Non responders
surgical history


Previous Knee Operations / Surgical Diagnosis
Lateral Meniscal Tear
10
Medial Meniscal Tear
34
Meniscal Cyst
2
Normal Arthroscopy
10
Medial Ligament Tear
10
Partial ACL Tear
2
Anterior Cruciate Rupture
8
Posterior Cruciate Rupture
2
surgical pathology
0
5
10
15
20
25
30
35
Number identified at operation


Pattern of Anterior Cruciate Injury
number of injuries
0
0.5
1
1.5
2
2.5
3
3.5
4
ACL Tear Only
ACL and MCL Tear
ACL and PCL
Partial Tear ACL
Partial ACL and MCL
surgical pathology


Knee Surgery by Position
180
160
140
120
100
80
60
40
20
0
number of players
167
149
116
41
38
10
14
13
2
4
Goal Keepers
Defenders
Midfield
Forward
Utility
Knee Surgery by Position
All Players by Position

5 Results - Preseason Assessment

5.0 Introduction

The preseason is a traditional period, averaging 4 to 6 weeks, which precedes the start of each season. This period is generally regarded as the most physically intense period of the soccer calendar, when players can be pushed to their physical limit, free of the demands of competitive football. Essentially the preseason aims to restore and ultimately optimise match fitness.

The design of Scottish professional preseason has changed little over the last 40 years. Players are rapidly introduced into rigorous daily routines despite their summer excesses.

This study was designed to provide a unique insight into the suitability of the current preseason routine. Twenty-seven Scottish Clubs (Figure 1) were studied to assess the aetiology of injuries arising during preseason. This is the first sports injuries study to assess specifically the demands of the preseason period in British football.

Non Responders

Of the 27 Scottish football clubs who agreed to participate, 24 clubs completed this study (436 players). This involved a pre- and post-preseason assessment of 18 players from each club. All injured players were subsequently reassessed weekly for the first 12 weeks of the season to identify any recurrence or further injury.

5.1 Format of Preseason

Although a general stereotype can be constructed for the average preseason of Scottish clubs, it is difficult without performing a complete field study to assess in detail the workload associated with this intensive conditioning period. Each club was asked to detail for each week of the preseason, the number of training sessions and matches played. A clear pattern arose from this assessment of the 24 clubs involved. The preseason lasted (on average) four or five weeks and occasionally six. The preseason involved predominantly training sessions during the first two to three weeks with the gradual introduction of training matches as the number of training sessions were tapered. Premier clubs were noted to have more frequent training sessions, sometimes as high as ten sessions per week for the first few weeks of the preseason. In contrast, some of the First and Second Division clubs undertook, on average, four training sessions per week initially, which reduced to two or three once the competitive matches began. Although this summary is representative of the overall trend, certain clubs appear to have a slightly irregular preseason structure which may have depended on the availability of players or match fixtures. Certain clubs also participated in a small preseason tournament.

5.1.1. Injuries as They Relate to Individual Teams

It has already been explained why individual teams in this study were not compared directly. It may have been interesting to compare injury rates with preseason levels of activity but such an analysis may be misleading for the following reason: a club may well report a high frequency of training activities, but the content of these individual sessions may vary and a field study would be required for adequate analysis. This overall difficulty in assessing injury rates as they relate to individual team activity, highlights the difficulty with standardising risk assessment for soccer participation.

5.1.2. Aetiology of Injury

To fully appreciate the aetiology and mechanism of injury during the preseason it is important to establish whether or not an injury arose from direct contact with another player. It is also important from an injury prevention perspective to identify whether most of these injuries arose during routine training sessions, within the preseason, or during competitive preseason matches.

5.1.2.1. Contact or Non Contact

In total 123 significant injuries were reported, which represents more than 1 in 4 of the 414 players who were fully assessed during the preseason period. Figure 2 details the breakdown of significant injuries reported according to their aetiology. It is worth recording that the three clubs who failed to complete the preseason assessment included; Hamilton Football Club which appeared to have difficulty in obtaining the appropriate medical information, Dundee United FC who did not have permanent medical staff and Forres Mechanics who understandably due to the size of the club were unable to participate fully.

Non contact injuries predominated during the preseason (53.7%); these principally involved the thigh (14), achilles / ankle (12) and groin (9), respectively. Figure 2 illustrates the surprising frequency of non contact injuries, although, certain authors would have argued that this could have been anticipated due to inherent overload and overuse associated with this intensive training period.

Contact injuries accounted for 44% (55) of preseason injuries, and predominantly affected the lower limbs. As illustrated in Figure 2, kicks accounted for 11.2% of preseason injuries, whereas tackles represented 24% of preseason injuries and collisions the remainder.

5.1.2.2. Injured During Training or Match

Most contact injuries during preseason arose during practice matches (91%). Of this number 70% of injured players understandably left the match prematurely for further assessment and treatment. Relatively few of these injuries were subsequently reported as recurring. In contrast, 50% of non contact injuries occurred during training and the remaining 50% during preseason matches (29 of 60).

Non contact injuries arising during training matches are often treated less seriously than contact injuries and 70% of the players went on regardless of injury to complete the competitive match. This may be reflected in the fact that 30% of non contact injuries subsequently recurred.

5.2. Area Injured

Collisions were responsible for most of the contact injuries involving the upper limb (4), but the knee and hip were also strongly represented. Kicks accounted for 11.2% of preseason injuries and frequently resulted in ankle and calf injuries, whereas tackles represented 24% of preseason injuries and principally exposed ankle and knee to injury. Collectively it was apparent that contact injuries most frequently resulted in ankle (17) and the knee injuries (12). Figure 3 details preseason contact injuries according to aetiology and the area affected.

There appear to be a significant spread of non contact injuries principally involving the thigh and groin (34.5%) followed by the ankle and Achilles (18.2%). The knee was also noted to be vulnerable to non contact injuries, although the effect of previous injury was difficult to assess. Figure 4 details the non contact injuries according to the area affected.

5.2.1. Player Position

All players regardless of playing positions sustained a similar percentage of contact and non-contact injuries during the preseason. Figure 5 breaks down all injuries according to position and the subgroup of non contact injuries are similarly classified. By subtracting the difference between each column for the different positions it is possible to assess the number of contact injuries.

5.3. Injury Recurrence

Interestingly, one in three non contact injuries during preseason were reported as recurrent (28.8%), this figure relates to the recurrence of injuries sustained either during the close season, or the previous season. Three of these players subsequently required surgery. (2 groin operations and one achilles exploration). Of particular importance to the soccer player is that 50% of the 64 players who sustained a non contact injury during the preseason period, subsequently sustained an injury during the first twelve weeks of the season. Figure 6 illustrates the breakdown of these second injuries according to their aetiology, 50% (17) of which were non contact injuries and the other 50% contact injuries (17). Further analysis confirmed that 30% of the second injuries or 60% of those sustaining a further non contact injury were actually a recurrence of the preseason injury. 25% of this subgroup (9) had more than two significant injuries during the first three months of the season. Injury recurrence was not found to be a significant problem with contact injuries.

5.4. Discussion

The object of the preseason is to achieve optimum match fitness and in turn performance. It is clear from this study that for one in four players this is not possible because of injury and for a significant percentage the experience is harmful.

Non contact injuries represent the greatest challenge, accounting for 53% of all preseason injuries. One in three of these non contact injuries were classed as recurrent (29%). This level of injury recurrence suggests that previous rehabilitation has been inadequate and that pre-existing weakness have not been clearly identified, before the preseason commenced. This risk could be reduced by introducing routine preseason physicals, as used in other sports. This theoretically would identify weaknesses and encourage guided rehabilitation.

Fitness

The overall objective of physiological analysis is to provide an insight into the demands of a competitive match so that training can be appropriately planned to optimise performance and prevent injury (Reilly and Thomas 1976). Van Gool (1987) concluded that during the match players covered 10,225 metres (± SD = 580 metres). Of this 42.9% was described as low intensity and 42.6% was of medium intensity and 7.5% high intensity. Overall analysis suggests that work rate during play demands that a footballer should be able to run 9 to 12 kilometres, more or less continuously. They should also have the physiological capabilities for high level intermittent exercise, with a ratio of low intensity to high intensity of approximately 2.2 to 1 by distance. Sprints appear to be relatively short averaging 15 metres once every 90 seconds (Reilly and Thomas, 1976). Players should be sufficiently fit at the start of the season to cope comfortably with these demands. Smaros in 1980, confirmed a strong correlation ($R = 0.89$; $N = 8$) between V_{O2} max and distance covered in a given match.

Weight

There is a tendency with age to carry an increasing amount of weight and in footballing terms any additional fat can be regarded as an unproductive dead-weight. A player who increased his level of activity and training input may well increase his weight, although when assessed physiologically his percentage of body fat may well have been reduced and subsequently replaced by muscle. A more troublesome problem is weight gain between seasons.

In this study because of the inconsistent timing of weight measurements with regard to hydration and exercise, firm conclusions cannot be drawn. It would have been interesting to know the fighting weight of players at the end of the previous season. One of the more extensively studied aspects of the British game has been that of basic height and weight assessment with studies by Reilly (1979) of the English League and subsequently by White *et al* (1988). In White's study the average height was 180.4 ± 1.7 cm and the body mass averaged 76.7 ± 1.5 kg. Although players traditionally tended to carry a little more than their ideal weight when compared with other athletes the pattern appears to be changing. The one record of a Scottish club was that of Aberdeen FC in 1974 with an average percentage of body fat of 14.9% which was considered high. However in White's study in 1988 for a top English team a preseason body fat percentage of 19.3% was recorded which is clearly too high. This is assumed to reflect the relative inactivity and excessive food intake of the closed season combined with the inability of the players to discipline themselves.

Of the players sustaining contact injuries, 91% occurred during training matches, and only 30% of players continuing to participate. Seventy percent of players sustaining non contact injuries during play went on to complete the preseason match. This level of injury frequency could certainly be reduced by encouraging players to declare injuries in order to provide immediate treatment and rehabilitation.

The thigh and groin are especially vulnerable to non contact injuries which can prove extremely troublesome to manage as reflected in the fact that two players during preseason required groin surgery. The next most frequently affected areas are the achilles tendon, ankle and knee respectively.

Overtraining

Non contact injuries are generally due to overload or overuse although it is recognised that non contact injuries can arise when physiological loads are applied to tissues which are rendered vulnerable through previous injury or illness. Overload and overuse injuries can also arise when a player tries to resume a previously held level of activity too rapidly . For example, it is known that 7% of fast twitch fibres may disappear after three weeks of rest. During this period of inactivity basic cardiovascular fitness is significantly compromised. If the preseason demands are in excess of the physiological capacity of the individual to adapt, or if recovery periods are insufficient, then injuries will arise.

The Doctor should agree with both trainer and manager upon the desired training objectives and should re-emphasise the importance of injury prevention. Prevention would include a medical input into the warm up, stretching routines and cooling down periods (Safran et al 1988). Cooling down is to facilitate training adaptation, to improve mobility and some would argue to enhance psychological, neurological, endocrinological and immunological states of health (Liesen and Hollman, 1981).

Muscle injuries, particularly contusions and strains, are one of the commonest injuries to present in sports and in particular soccer. (Ekstrand, 1982). Muscle strains are extremely common, especially in contact sports. They can result if muscle is distracted, often across two joints, for example, the quadriceps and the gastrocnemius. The effect of muscular action across two joints is dependent upon sensitive neuromuscular system, involving effective proprioceptive input, to facilitate co-ordination and the avoidance of excessive fatigue. (Renström, 1985). Muscle strains occur predominantly during eccentric activity and more significant pathology, in particular partial rupture, occurs primarily adjacent to musculotendinous junctions. (Garrett *et al* 1987). From the same work, it was concluded that a muscle disruption occurs when stretched to a given length, whether activated or not. If the muscle is activated, it can absorb more force and therefore muscle activation when stretched acts protectively.

Two important factors can influence the susceptibility of muscle to strain injury. Muscular fatigue, which has been discussed in detail (physiology section) can significantly affect the ability of muscle to absorb energy and therefore players undertaking explosive activity, such as sprinting at the end of a training session, may well be more exposed to injury. Muscle strains most often occur during eccentric activation. The location of injury is primarily adjacent to the musculotendinous junction and the viscoelastic characteristics of muscle clearly demonstrate that fatigued muscles can absorb less energy prior to failing than a glycogen replenished muscle. Injuries are more likely if warm-up is incomplete or inappropriate (Reilly and Stirling, 1993). The soccer player is associated with decreased muscle flexibility, in particular affecting the hamstring and hip adductor muscle group (Ekstrand, 1982). Although the natural history favours recovery, recurrence is frequent and treatment has to be orientated as much towards prevention as to recovery (Garrett, 1990).

Sport induced soft tissue injury and tendinitis have been extensively studied. The analogy between tendon injury and stress fractures of bone described by Clancy (1994), seems to be appropriate. Intrinsic and extrinsic factors can both contribute to tendinitis, although it is unusual for it to arise without excessive physiological load. Intrinsic factors, although less significant, may well accentuate tendon injury and delay repair.

It is accepted that loading, especially if rapid excessive and repetitive, carries the highest risk of developing a tendinitis. A gradually applied force even of the same magnitude is less likely to be as injurious. The same principle applies for the removal of force. If a force is removed rapidly a greater degree of tendon disruption occurs (Knorzer *et al*, 1986). As with muscle activation the greatest tendon forces are generated during eccentric muscular contraction and this is when tendon is vulnerable and at risk of injury. (Curwin *et al*, 1984).

Training Surface

As previously detailed overuse injuries can be attributed to both intrinsic and extrinsic factors. Biological tissues are not inert and change and adapt according to the functional mode applied. Overall inherent strengths can be affected by; exercise, immobilisation, stretching and ageing.. An extrinsic factor of some significance during the preseason is that of environmental conditions which can contribute significantly to the injury level, due to enhanced fatigue and dehydration produced by a warmer climate, as well as the punishing effect of training on hard, dry surfaces. Nigg and Denoth (1980) have shown that the playing surface can increase injury frequency, by four-fold for selected activities. For example, in tennis the injury frequency for surfaces which do not allow sliding, is at least 200% more than for surfaces that do allow sliding, such as clay and synthetic sand. This difference has not been so clearly established for soccer. Soccer epidemiology remains difficult to interpret due to differences in injury classification, control and follow up. A review of playing surface related injuries by the NCAA Injuries Surveillance System (1991), reported that in male soccer, there were 26% of injuries on natural grass and 28% on artificial turf. The match situation was comparable, with 22% of injuries resulting from those played on natural grass and 28% of those played on artificial grass.

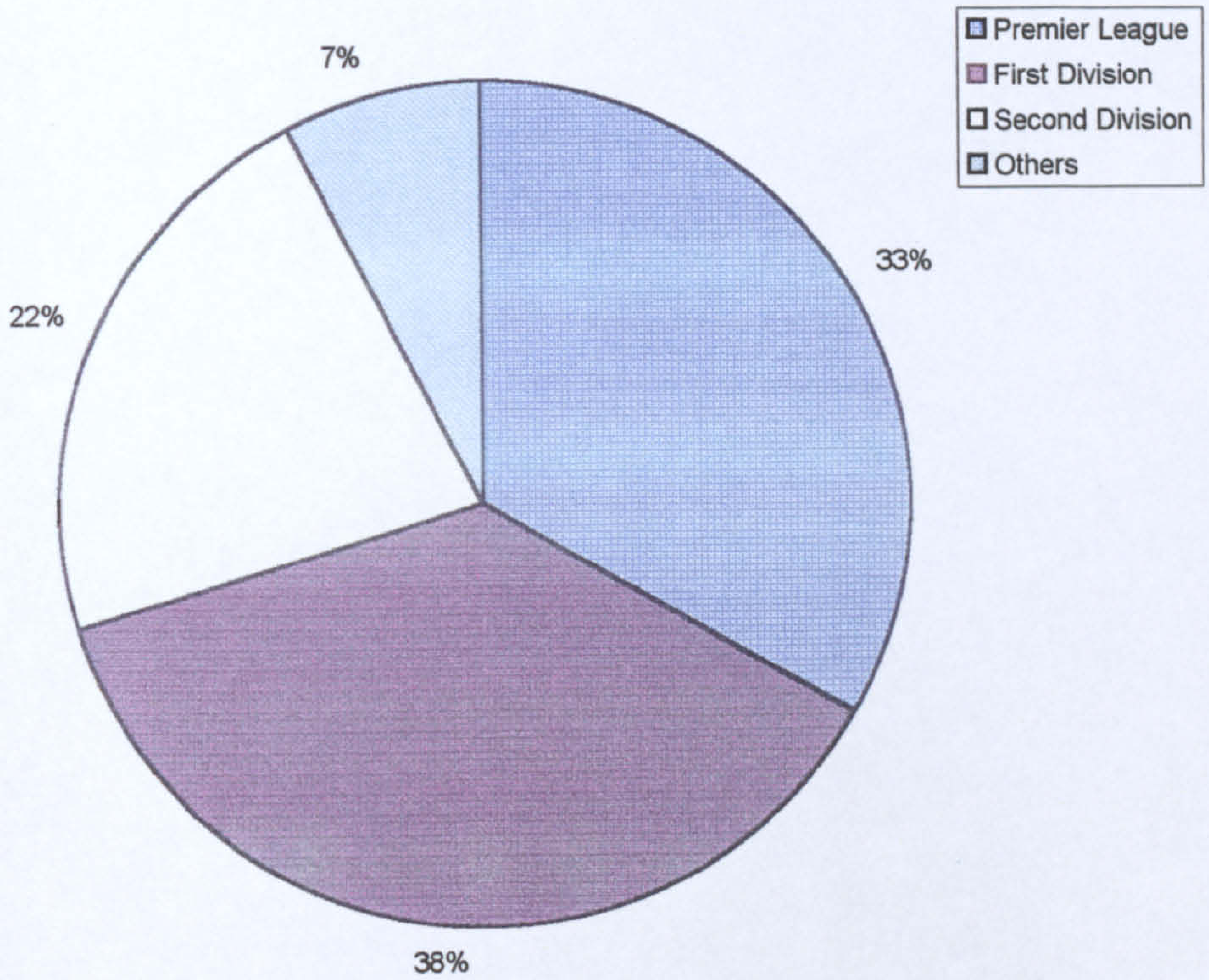
The most important factor, with regard to injury frequency is the frictional behaviour of artificial surfaces. Ideally a surface should provide a degree of sliding, yet enable a player to maintain sufficient traction to keep his balance. Other aspects such as cushioning of artificial surfaces have been investigated but appear to be less significant.

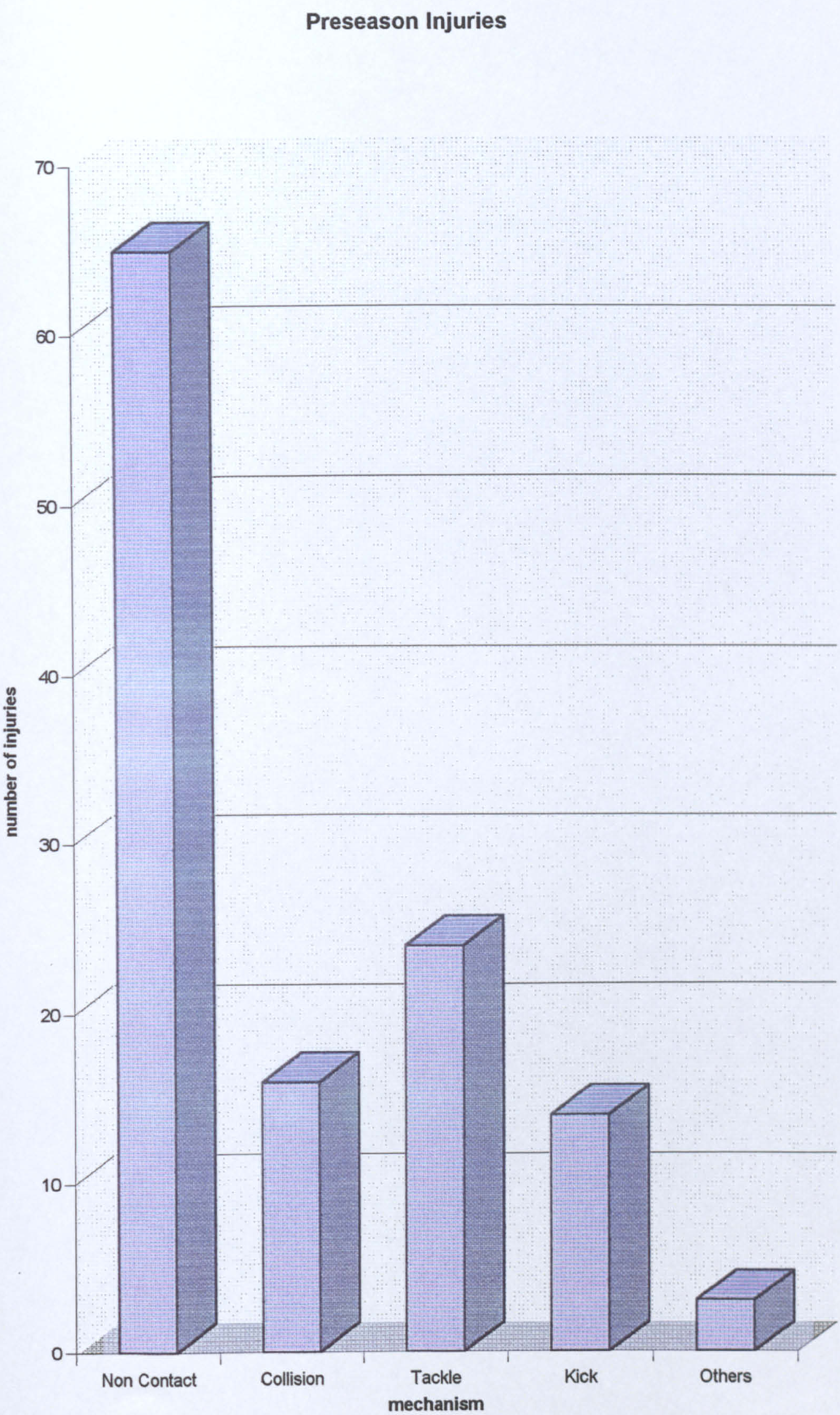
In attempting to optimise fitness, injury prevention must remain paramount. The demands of the preseason need not be excessive, although a high workrate potential may contribute to a team's success. It is clear from this study that contact injuries could be minimised during friendly preseason matches. The knee is particularly vulnerable while tackling which suggests that standard tackling techniques could be improved.

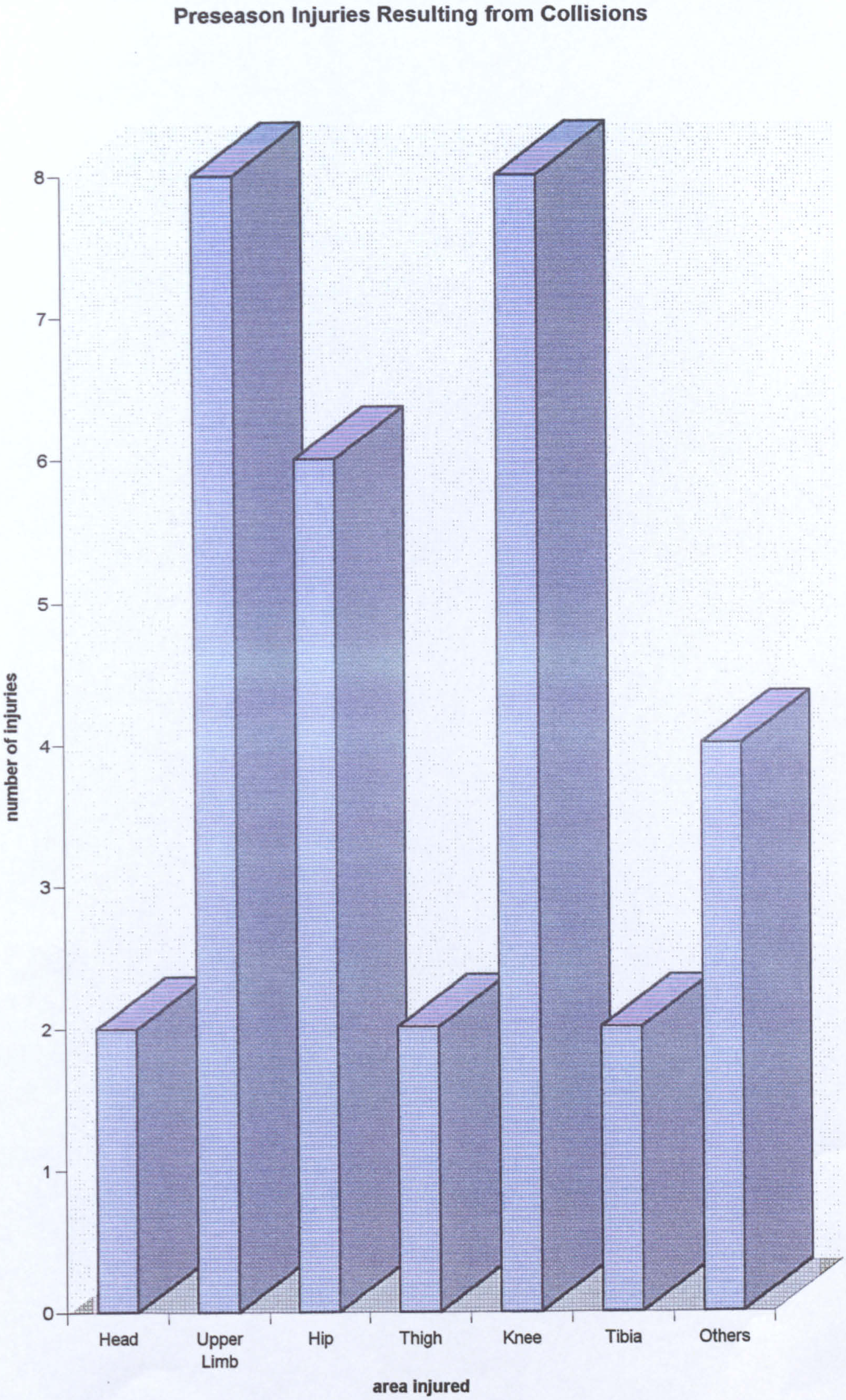
Strengthening exercises should be encouraged to maintain strength during the close season. Strength training improves both muscular strength and kick performance (Proft *et al*, 1988). The balance however between quadriceps and hamstring strength has been much debated, in particular whether imbalance predisposes to injury in football (Fowler and Reilly, 1993). The most important use for this ratio is that if a pre-injury level can be re-established, then it can be used as an endpoint for rehabilitation. Kicking clearly exposes the ankle and calf to injury and protective ankle and shin guards should be worn for preseason training.

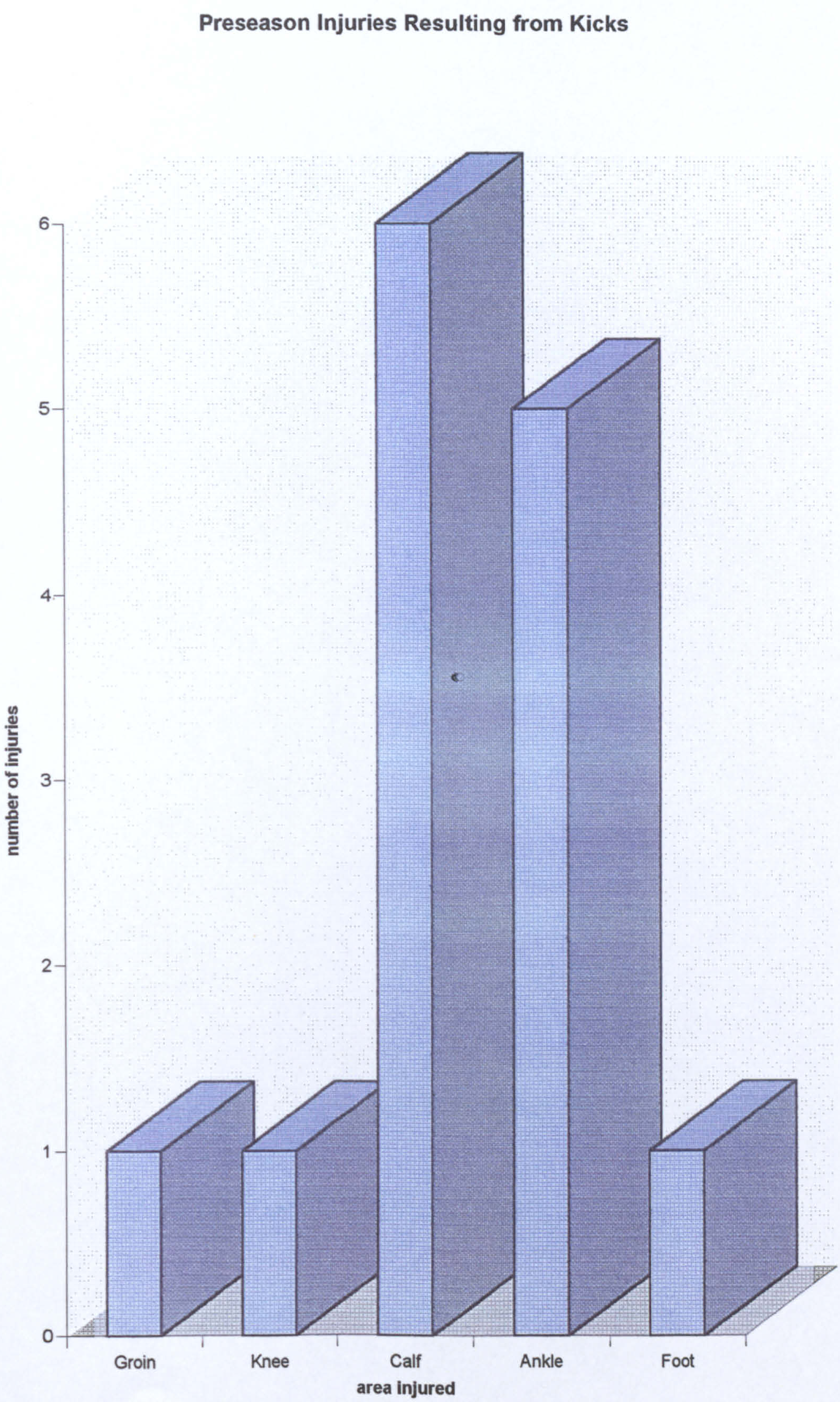
It is apparent from the follow up in this study of players who sustained preseason injuries, that the preseason itself represents a crucial phase of the overall season. If non contact injuries do occur, then 50% of players will develop a second injury early in the season and 25% of this number will have more than two subsequent injuries during this period. Considering it may take several weeks for a player to regain his endurance capacity after injury (Ekblom 1994), the cost of the current preseason structure is clearly too high. The focus of a successful preseason must be to prevent injury only then will optimal match fitness and team stability be achieved. If this study's recommendations are not taken on board it is likely that approximately one in four players will continue to have to suffer the burden of injury which may completely disrupt the first half, if not the complete season. Future research should address all aspects of overtraining during the preseason in detail, now that the aetiology and frequency of injury has been established.

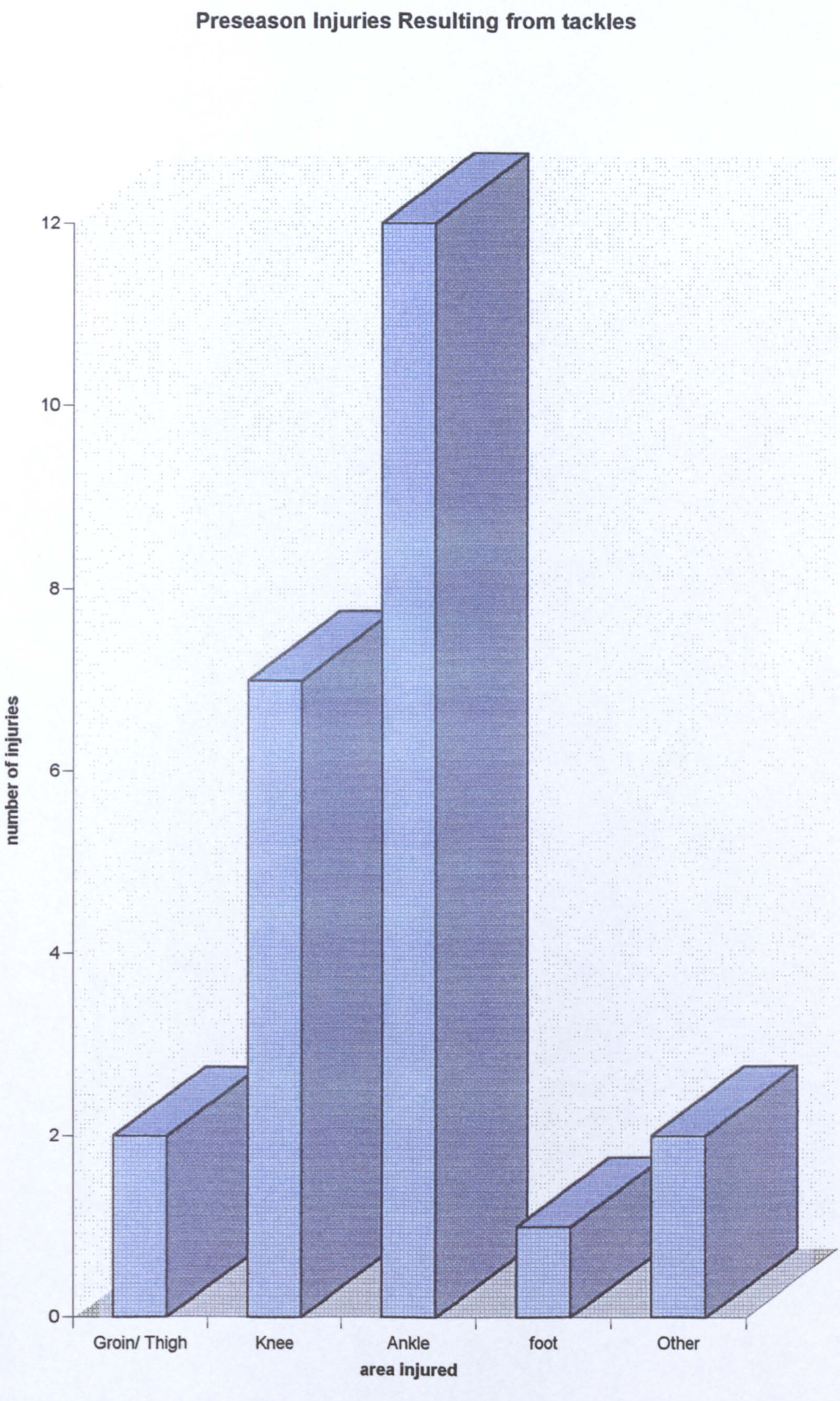
Composition of Study Group

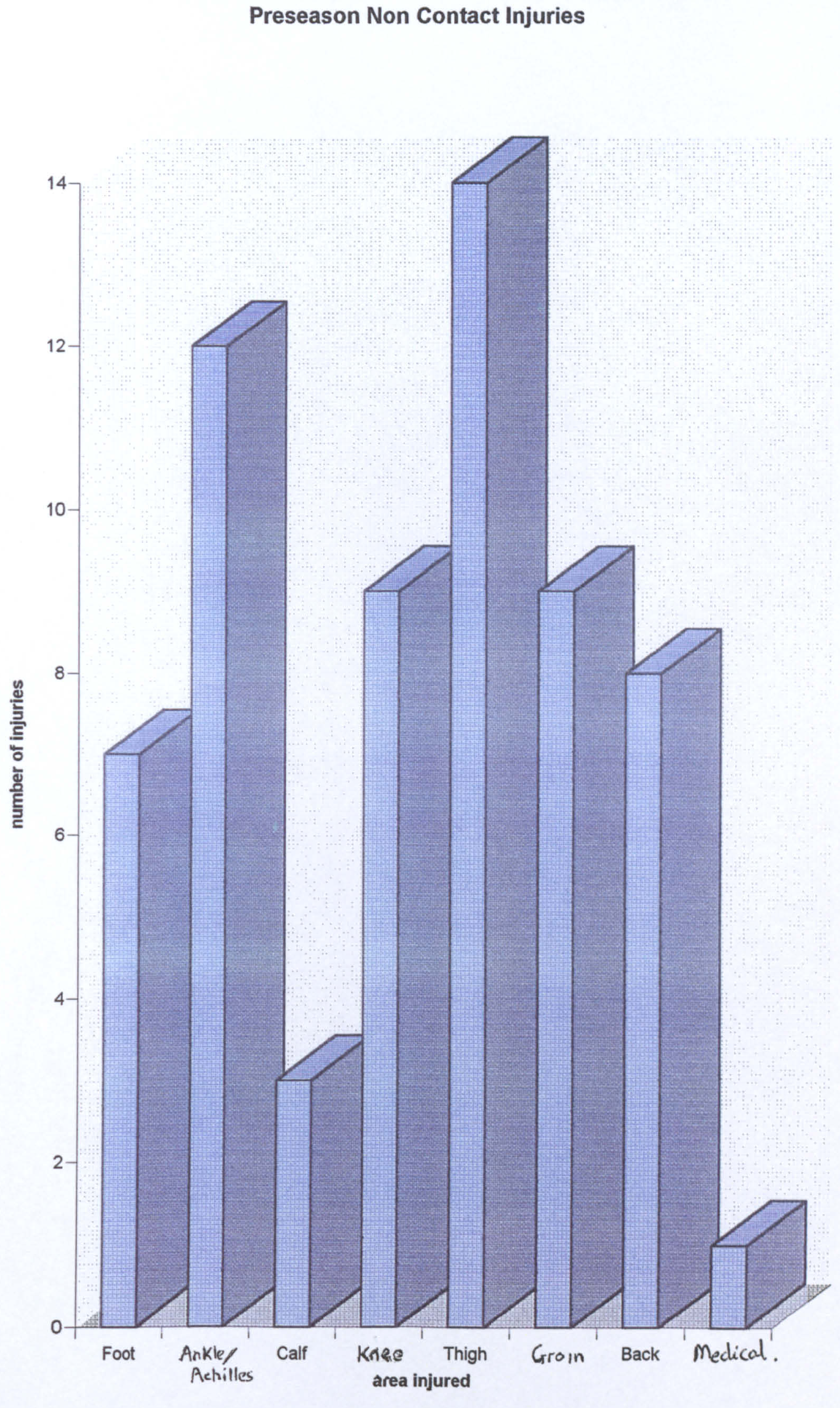


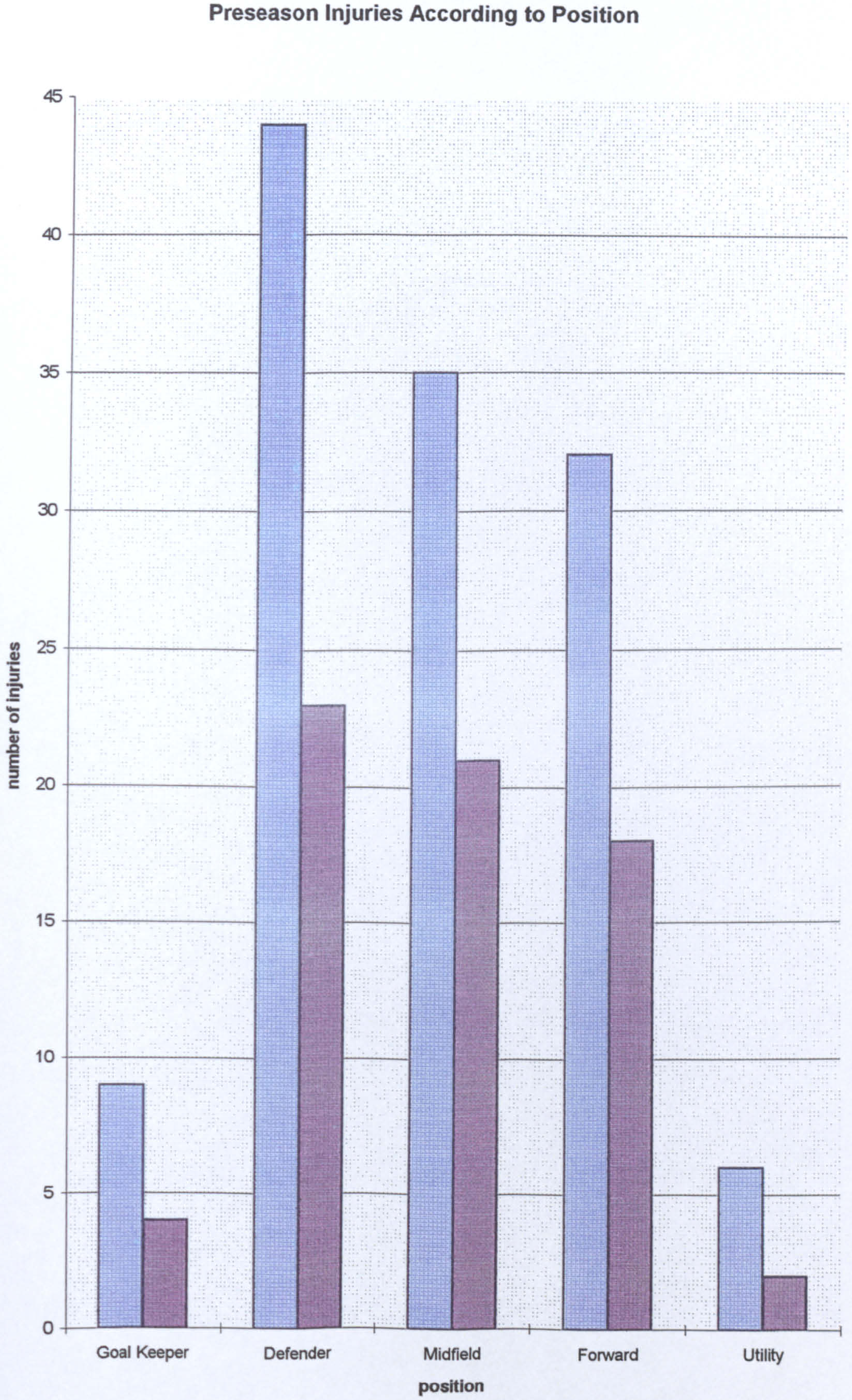

Preseason Injuries
number of injuries
0
10
20
30
40
50
60
70
Non Contact
Collision
Tackle
Kick
Others
mechanism

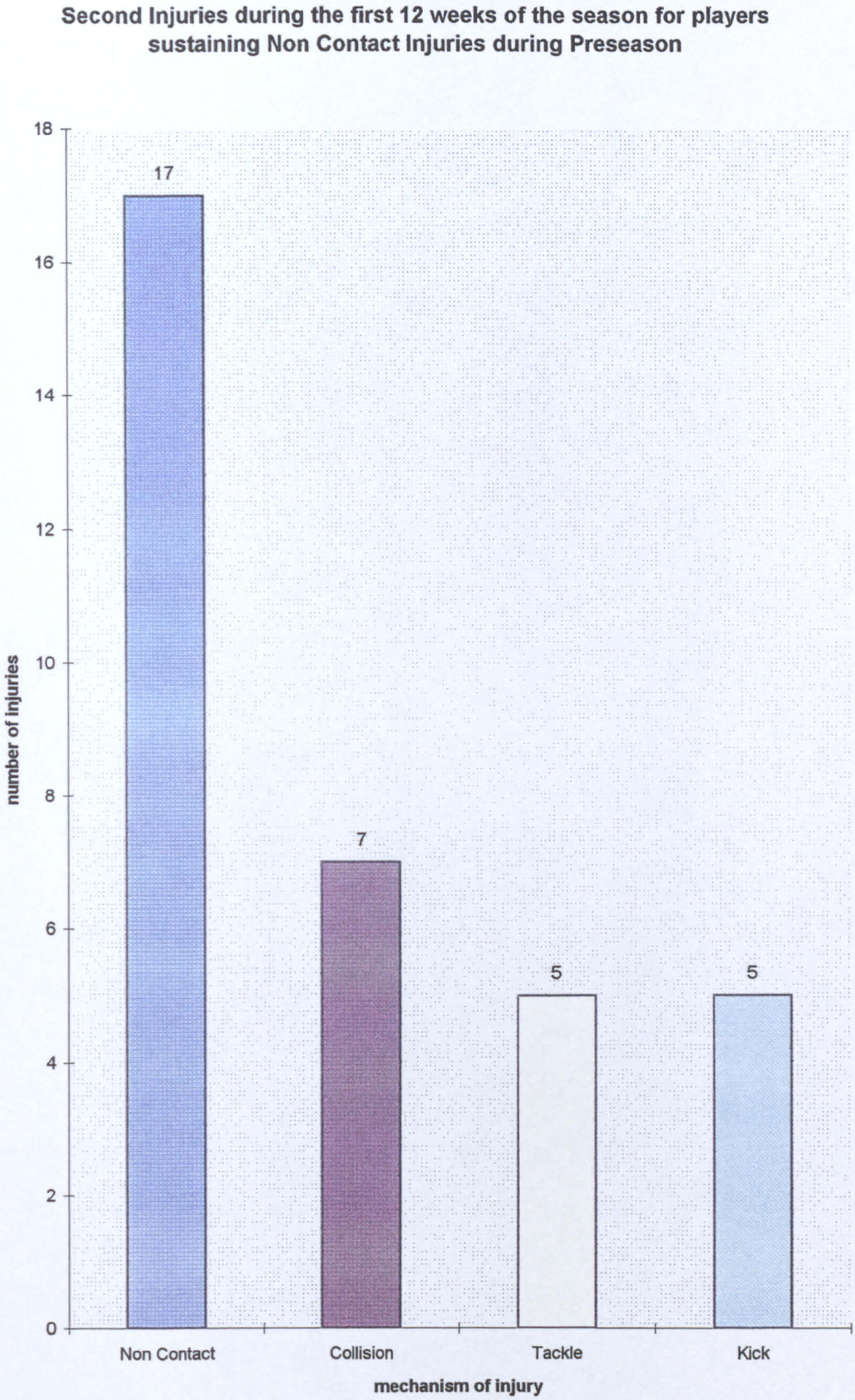

Preseason Injuries Resulting from Collisions
8
7
6
5
4
3
2
1
0
number of injuries
Head
Upper Limb
Hip
Thigh
Knee
Tibia
Others
area injured


Preseason Injuries Resulting from Kicks
number of injuries
0
1
2
3
4
5
6
Groin
Knee
Calf
Ankle
Foot
area injured


Preseason Injuries Resulting from tackles
number of injuries
0
2
4
6
8
10
12
Groin/ Thigh
Knee
Ankle
foot
Other
area injured


Preseason Non Contact Injuries
number of injuries
0
2
4
6
8
10
12
14
Foot
Ankle/ Achilles
Calf
Knee
Thigh
Groin
Back
Medical.
area injured


Preseason Injuries According to Position
45
40
35
30
25
20
15
10
5
0
number of injuries
Goal Keeper
Defender
Midfield
Forward
Utility
position


Second Injuries during the first 12 weeks of the season for players sustaining Non Contact Injuries during Preseason
number of injuries
0
2
4
6
8
10
12
14
16
18
17
7
5
5
Non Contact
Collision
Tackle
Kick
mechanism of injury

6. Results - Weekly Assessment During Season.

6.1 Introduction

Epidemiology is the study of how often disease occurs within a defined group and why? Epidemiological information can then be used to plan and evaluate strategies to prevent injury and provide a guide to the management of injured players. To ensure as large a study group as possible from the population at risk, it was decided to collect accurate and valid injury data on the same 480 players each week, for the entire season 1993-1994.

6.2 Results

After the initial pre-season study the participants were understandably surprised at the number of injuries identified and this helped to stimulate further interest. All 27 clubs participating in the study were randomly numbered. As can be clearly seen from the bargraph (Figure 6.1), the majority of clubs completed the full 40 week study period.

A few clubs dropped out at various stages during the season, some withdrawing abruptly and others tapering out and gradually losing interest. It was important to identify and explain non responders, although, in this study non responders are difficult to quantify. Seven clubs did drop out during the season, most of them within the first 10 to 15 weeks. One club managed to participate only in the first two weeks of the season and another withdrew immediately. A variety of reasons were offered which included; pressure of work, other commitments or a change of medical staff. Personal contact with individual clubs was maintained in order to encourage enthusiasm. There was some uncertainty regarding the accuracy of the weekly reports initially received from the clubs which subsequently withdrew from the study. For this reason, only the results from teams which completed the entire study period were used for analysis. Twenty clubs completed reports for the entire 40 weeks of the season, although one team tended to report their injuries in a rather variable manner including flurries of activity and prolonged periods of non reporting. For this reason the results of the remaining 19 teams were taken as being complete and accurate and used for analysis.

The number of teams initially participating were compared with those successfully completing the study (Figure 6.2). Two Premier Division clubs, three First Division and three Second Division teams did not complete the study. The remaining 19 clubs are composed of 7 Premier Division, 7 First Division, 3 Second Division and 2 other teams. Fewer Premier clubs dropped out probably due to the greater degree of medical supervision.

6.3 Player Position

After excluding the results of 8 teams as explained above, the playing positions of the remaining 342 players were studied. From the overall study population 11 goalkeepers, 39 defenders, 30 midfield players, 26 forward players and 1 utility player were lost to follow up. As illustrated (Figure 6.3), the overall composition of the study group remained essentially unchanged, with no significant shift favouring any particular player position.

6.4 Mechanism of Injury

A total of 677 injuries were reported for the 342 players. A broad overview of these injuries confirmed that the majority of injuries were non contact (322) although the total number of contact injuries was similar (307). Forty eight injury reports did not specify the mechanism of injury (Figure 6.4).

As detailed on the chart titled "Mechanism of Injury" (Figure 6.5), contact injuries were further subdivided into tackles (116), kicks (105) and collisions (83).

6.5 Anatomical Area Injured

All injuries were assessed by the areas affected as illustrated (Figure 6.5). The ankle (144) was the most frequently affected area, however the anatomical classification used included achilles injuries as ankle pathology. The next most frequently injured area was the upper leg (128), followed closely by the knee (117). The groin was also significantly represented (71) and if a similar convention had been used as described by other authors (due to the difficulty with diagnostic differentiation) the most frequently injured area would have been the upper leg/groin with a total of 199 injuries. Not surprisingly the neck, the upper arm and trunk were infrequently injured; players were however troubled with back injuries. For a total of 23 injuries the area affected was not specified.

6.6 Seasonal Pattern

The mechanism of injury according to date was assessed and is illustrated. A clear trend is apparent showing an increased frequency of contact injury during the first half of the season. Tackles in particular gave rise more frequently to injury during the first 15 weeks of the season (Figure 6.7). The incidence of non contact injury was reasonably consistent throughout the season, except during the first four weeks and in particular the second week of the season when there was a peak, with 21 injuries in the same week (Figure 6.8).

6.7 Pathology

Injuries were also assessed according to the underlying pathology (Figure 6.9). Ligament pathology (189 injuries) and muscular injury (186 injuries) were common presentations. Soft tissue injuries (119) were also frequently reported, whether involving intact or broken skin, and tendon pathology accounted for 57 injuries. Bone pathology accounted for 34 injuries which included 25 reported fractures and 9 stress injuries. Facial injuries were included within the bone pathology group.

A further subdivision of injuries according to the tissues affected has been illustrated (Figure 6.10). From this detailed analysis it is apparent that the commonest injury was that of a ligament sprain (164) followed by muscular strains (99). Within the group of soft tissue pathologies, 89 injuries involved extensive soft tissue bruising. Although bruising is a very general term covering a spectrum of injuries, it is worth emphasising that all injuries reported involved some degree of time loss from training or playing. Forty six tendinitis cases were reported, predominantly involving the achilles tendon (30).

More significant injuries involved complete soft tissue disruption, which included 25 ligament tears, 56 muscular tears and 11 tendon ruptures. The tendon ruptures involved a variety of anatomical structures including the groin, the anterior cruciate ligament, flexor hallucis longus and the achilles tendon.

6.8 The Pathology of Injuries by Mechanism

The prevention and treatment of common

pathologies could be improved if the aetiology and mechanism of injury were fully understood. Injury pathology was analysed in detail according to the mechanism of injury. Quite distinct patterns of injury appear when the injuries are broken down, as illustrated, into contact (Figure 9.11, Figure 6.12) and non contact pathologies (Figure 6.13).

Contact injuries are responsible for the majority of fractures (22) and extensive soft tissue injury (84), the majority of which arose from kicks (53). The commonest pathologies resulting from contact were ligament sprains (89) and ligament tears (19). Ligament strains are caused by a variety of contact mechanisms, principally tackling (64). Interestingly, muscle haematomata commonly arose because of contact but this does not appear to be related to collisions (6) or tackles (3). Kicks (41) were responsible for the majority of muscle haematomata.

Non contact injuries gave rise to a quite distinct range of pathologies. Muscle strains clearly predominated (134), followed by ligament sprains (68) which occurred slightly more frequently than tendinitis (43). As would be expected, few fractures were reported in this group, although eight cases of bone stress were identified. It is assumed that bone stress represents either stress fracture or medial tibial periosteitis. Interestingly 3 cartilage tears and 4 knee effusions occurred without contact injuries. Other significant soft tissue disruptions included 5 tendon ruptures, 5 ligament tears and 15 muscular tears. One shoulder dislocation also arose without contact.

6.9 Discussion

This is the most comprehensive soccer injuries study ever undertaken in British football and ultimately involved 342 players, who were studied on a weekly basis for a full season. This compares favourably with studies which are regarded as representing the Gold Standard in soccer injury epidemiology. Ekstrand and Gillquist (1983) studied half this number of players (180) which were from the Fourth Division of the Swedish Soccer League, representing a senior amateur as opposed to an elite professional standard. This study incorporated professional and semi-professional players across the spectrum of the four top leagues in Scotland. A total of 677 injuries were reported, which averages approximately 2 significant injuries per player per season. Direct comparison of soccer injury risk with other epidemiological studies is difficult as the majority of studies chose to express injury risk relative to an exposure rate. Such an exposure rate has been found to vary significantly. Jörgensen (1984) reported 4.1 injuries per thousand hours of exposure amongst senior male soccer players as compared to Ekstrand who reported an incidence of 7.6 per thousand hours of practice and 16.9 injuries per thousand hours of game exposure. The variability in this form of reporting relates to the averaging of estimated training times and the number of competitive matches per player. Obviously the intensity of competition and training is more important than the time involved.

The most frequently injured areas included the ankle (144), the upper leg (128), the knee (117) and the groin (71). These areas are considered in detail and discussed in the context of current literature in Chapter 9.

In this study a seasonal pattern was apparent when injuries were broken down according to the mechanism and analysed. Contact and non contact injuries because of their differing aetiologies were independently assessed. Contact injuries were more prevalent during the first half of the season, in particular as the result of tackles during the first 15 weeks of the season. Non contact injuries were also more prevalent at the start of the season, particularly during the first four weeks. This could represent a knock-on effect from the intense preseason period. In contrast, Latella *et al* (1992) studied in total 1018 athletes belonging to an Italian professional soccer team from Florence, over a period of 11 years. Although the climate in Italy clearly differs from our own, the season conforms to a similar pattern beginning in August with athletic training and ending in June at the completion of the various championships. They reported that their top professionals had a fairly uniform distribution of injury with no clear seasonal pattern.

An understanding of the pathology of the various injuries can help to focus preventative measures and stimulate research. Ligament (189) and muscular (186) injuries predominated. Further analysis confirmed that the ligament sprains represent the biggest preventative challenge accounting for 164 injuries followed closely by muscular strain (99).

The mechanism of injury requires to be understood if appropriate preventative measures are to be taken. In this study injuries were classified into contact and non contact injuries, although this logical approach has not been universally employed. Most injuries are simply classified into training or match injuries. Not surprisingly contact injuries gave rise to the majority of fractures (22); however, this number included facial fractures and few required surgical intervention (see Chapter 11).

Therefore the demand for orthopaedic surgical provision in soccer relates more to the management of ligamentous disruption, tendon pathology and meniscal injury than fracture management. Tackling clearly puts the ankle at risk of injury as the stability of the dorsiflexed mortice is often lost when kicking and as a result the commonest contact pathology was that of ligament sprain (89) and ligament tears (19). Ankle injuries and associated pathology are discussed in detail in Chapter 9.

Non contact injury accounted for 47% (322) of all injuries, most frequently resulting in muscular strains (134). This is clearly an area which can be targeted for preventative measures and is discussed along with the scientific theory in Chapter 9.

Surprisingly 68 ligament sprains occurred without contact and gave rise to concerns regarding both injury prevention and injury recurrence. These issues are discussed in detail in the chapter on "Injury Recurrence" (Chapter 10).

This unique and comprehensive overview of soccer injury epidemiology in British football, provides a scientific foundation for rational debate and will focus future research.

Returns Completed; a bargraph of the returns received from participating clubs during season 1993-4.

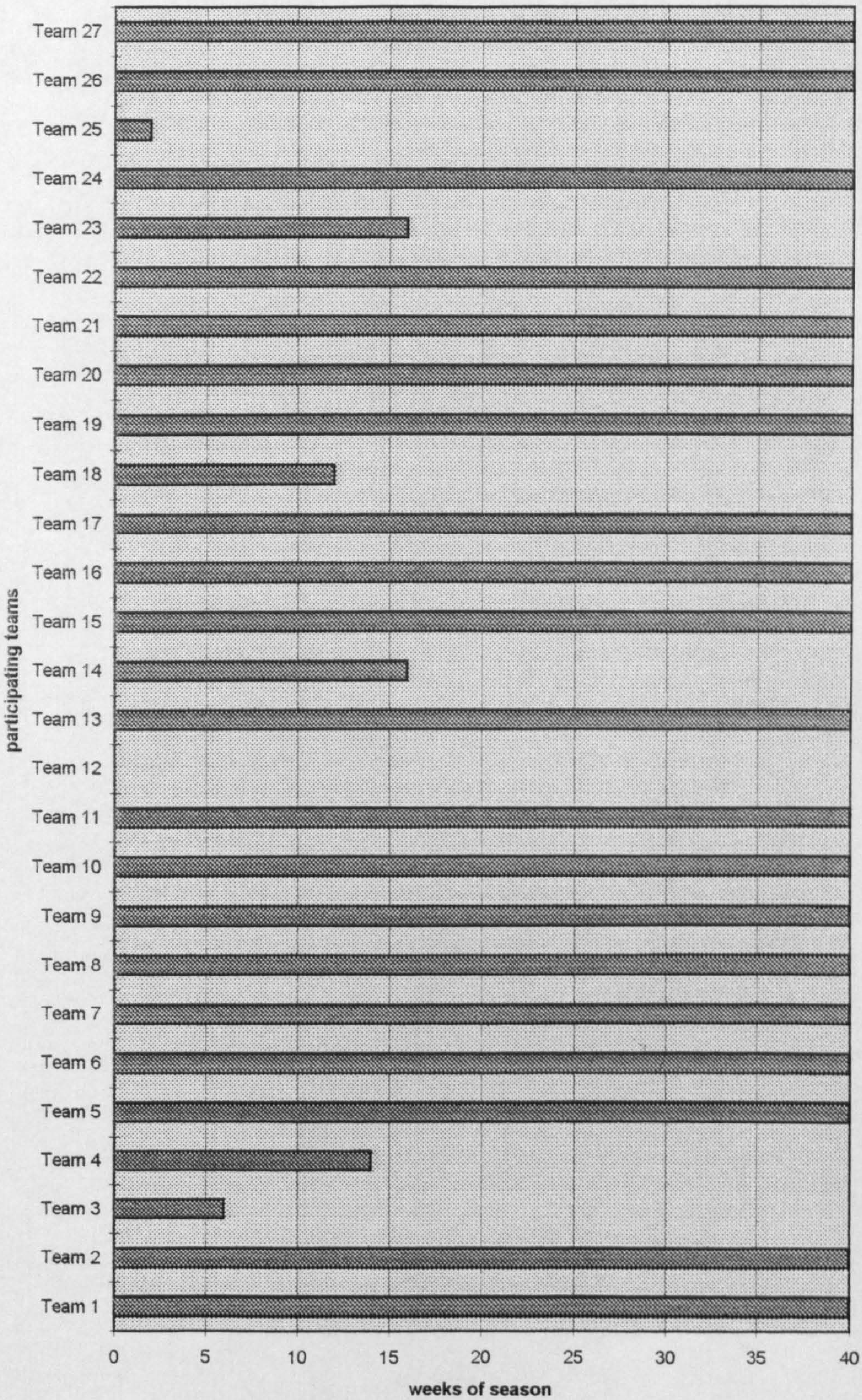


Fig.6.2.

	Teams Participating	*teams completing Study*	*teams incomplete*
Premier Division	9	7	2
First Division	10	7	3
Second Divsion	6	3	3
Others	2	2	0
	27	19	8

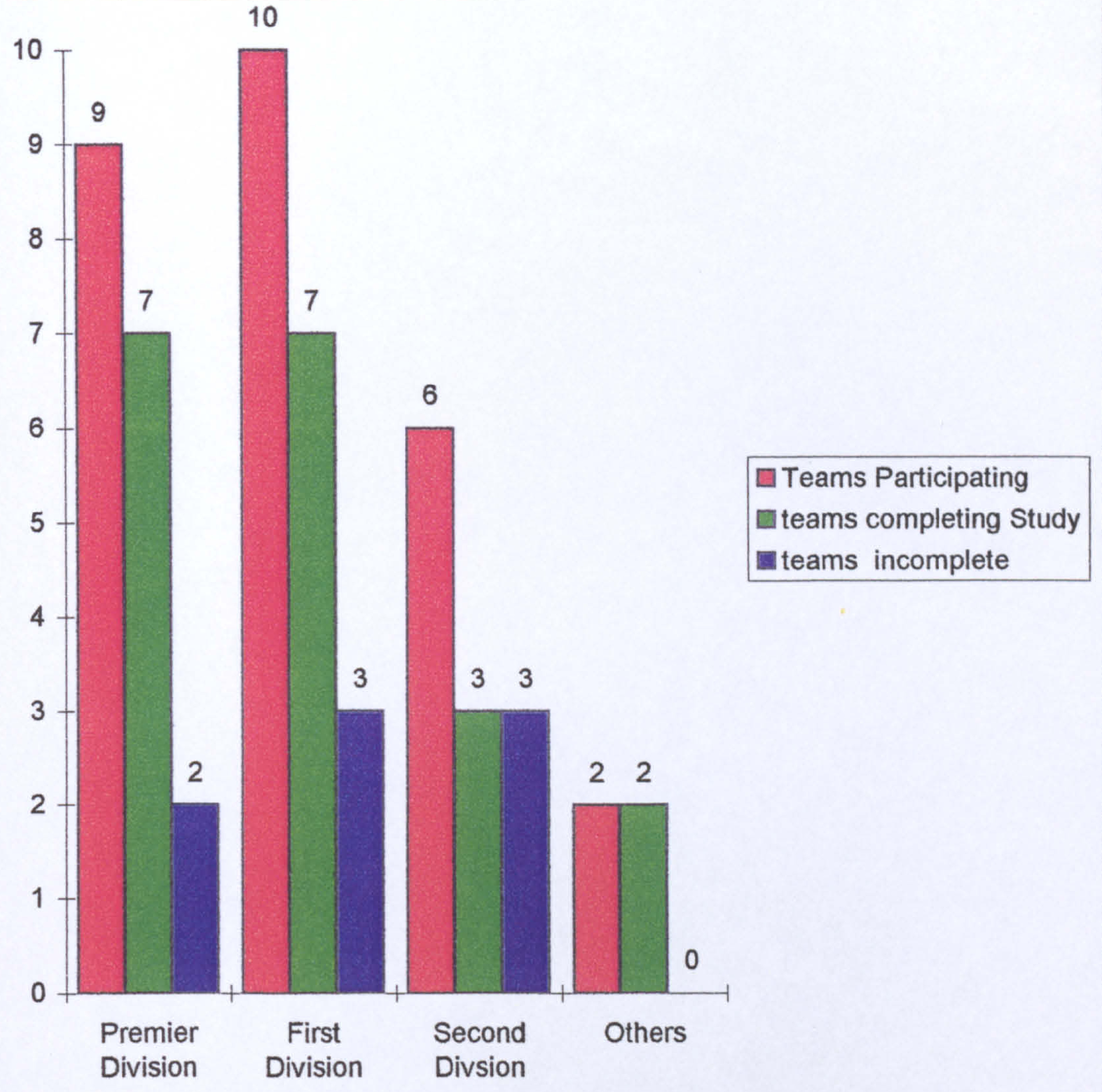


Fig. 6.3.

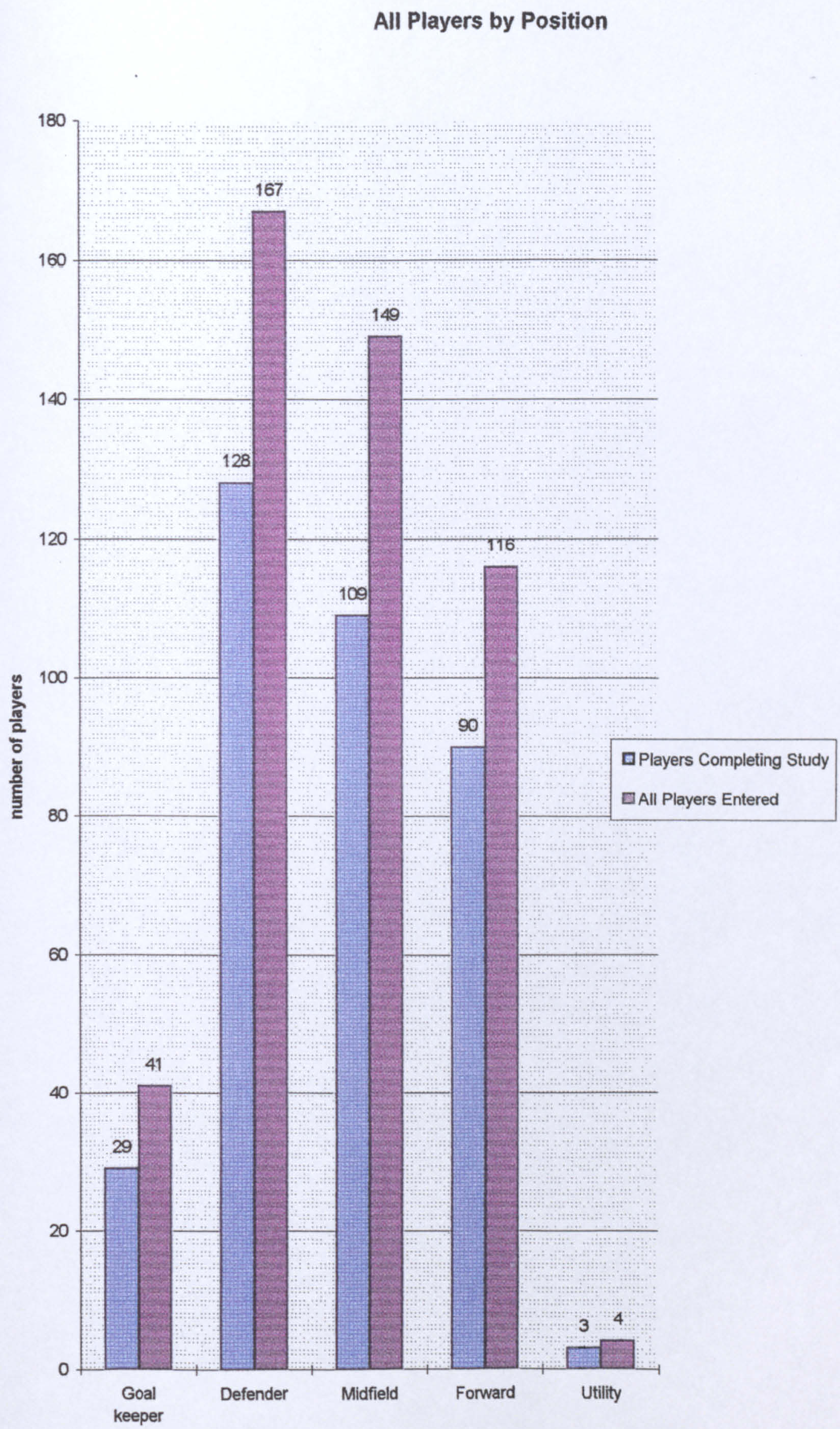

All Players by Position
number of players
180
160
140
120
100
80
60
40
20
0
167
149
128
116
109
90
41
29
3
4
Goal keeper
Defender
Midfield
Forward
Utility
Players Completing Study
All Players Entered

Fig.6.4.

	Total Number of Injuries
Not specified	48
Non contact	322
Contact	308
Total	678

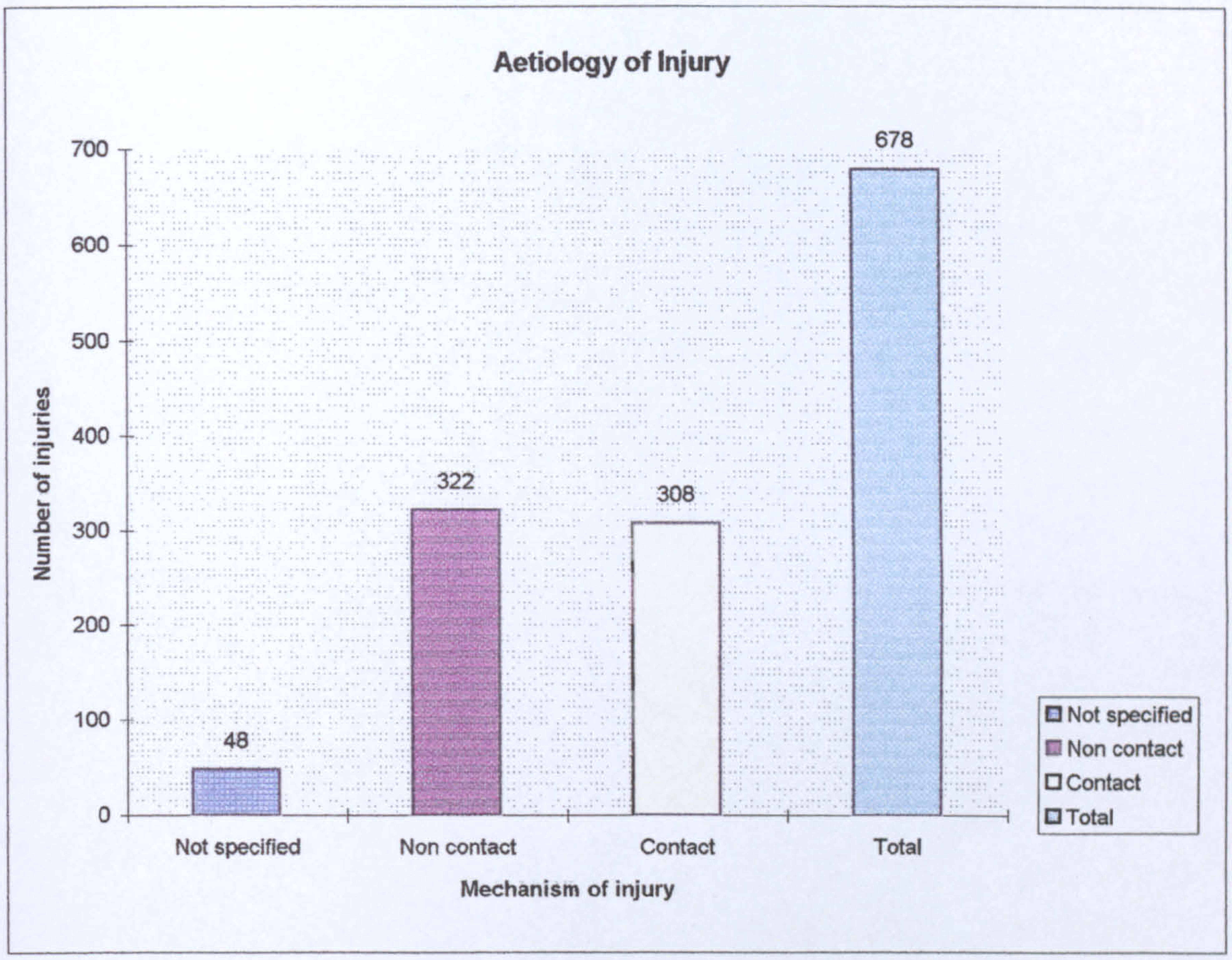


Fig. 6.5.

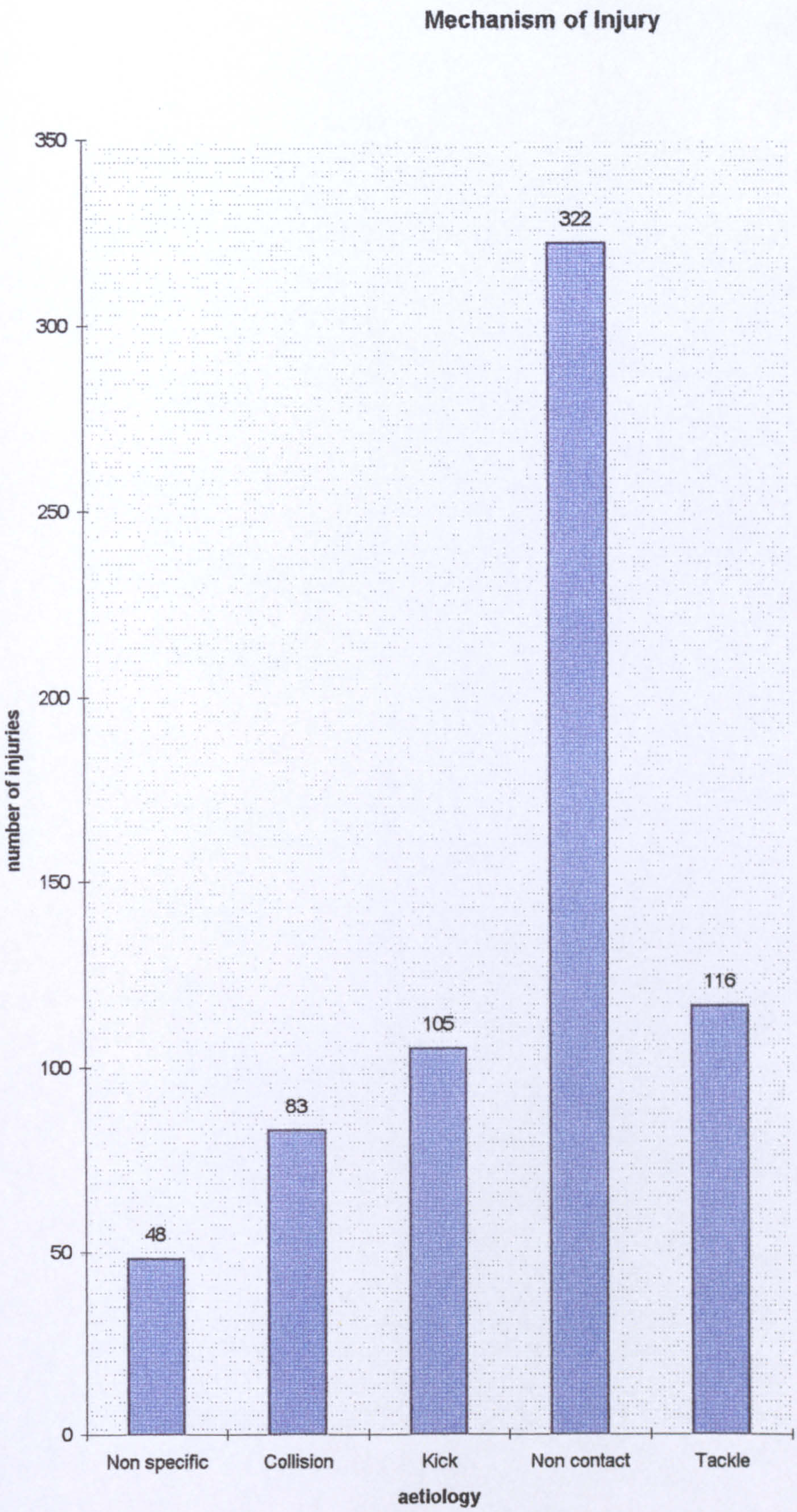

Mechanism of Injury
350
300
250
200
150
100
50
0
number of injuries
322
116
105
83
48
Non specific
Collision
Kick
Non contact
Tackle
aetiology

Fig.6.6.

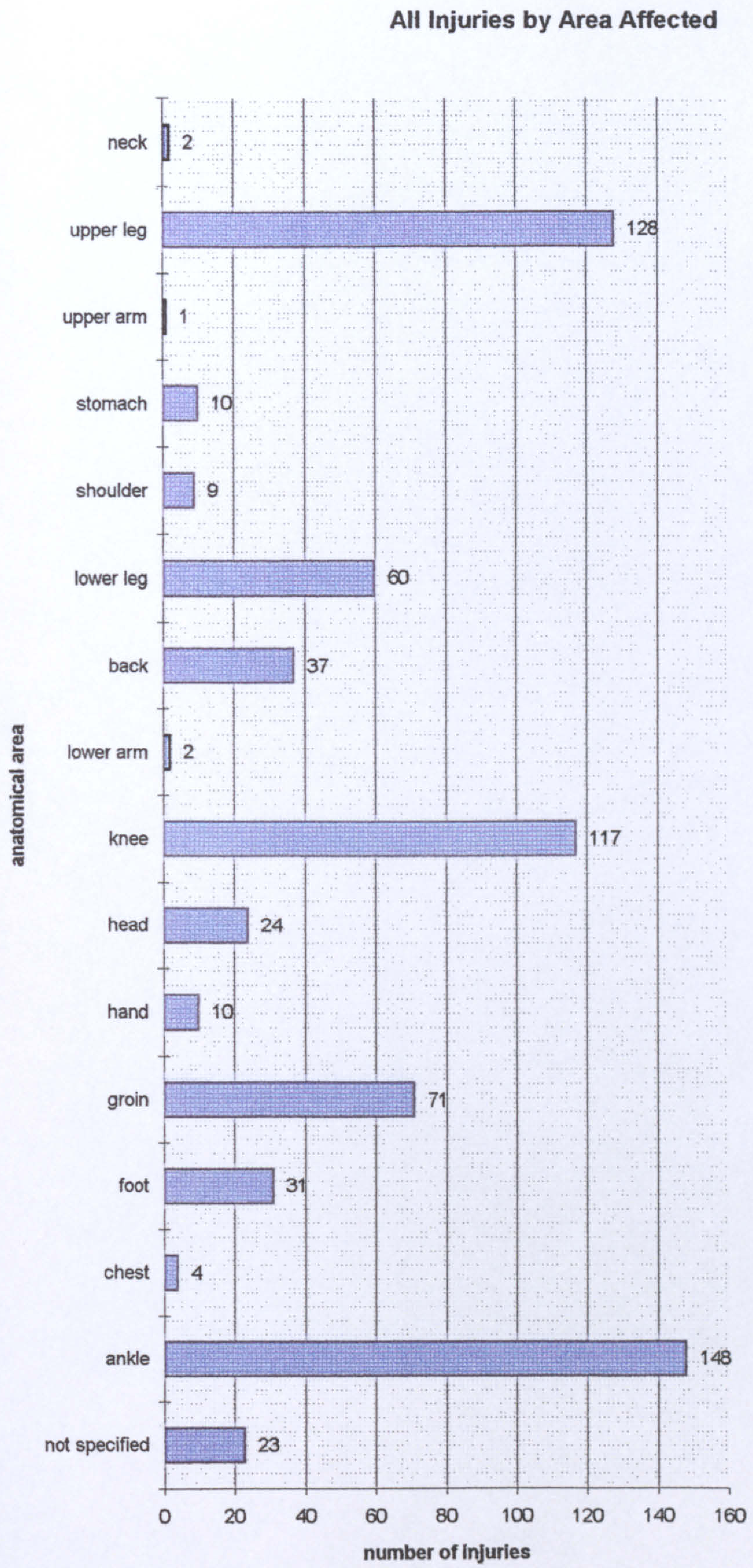
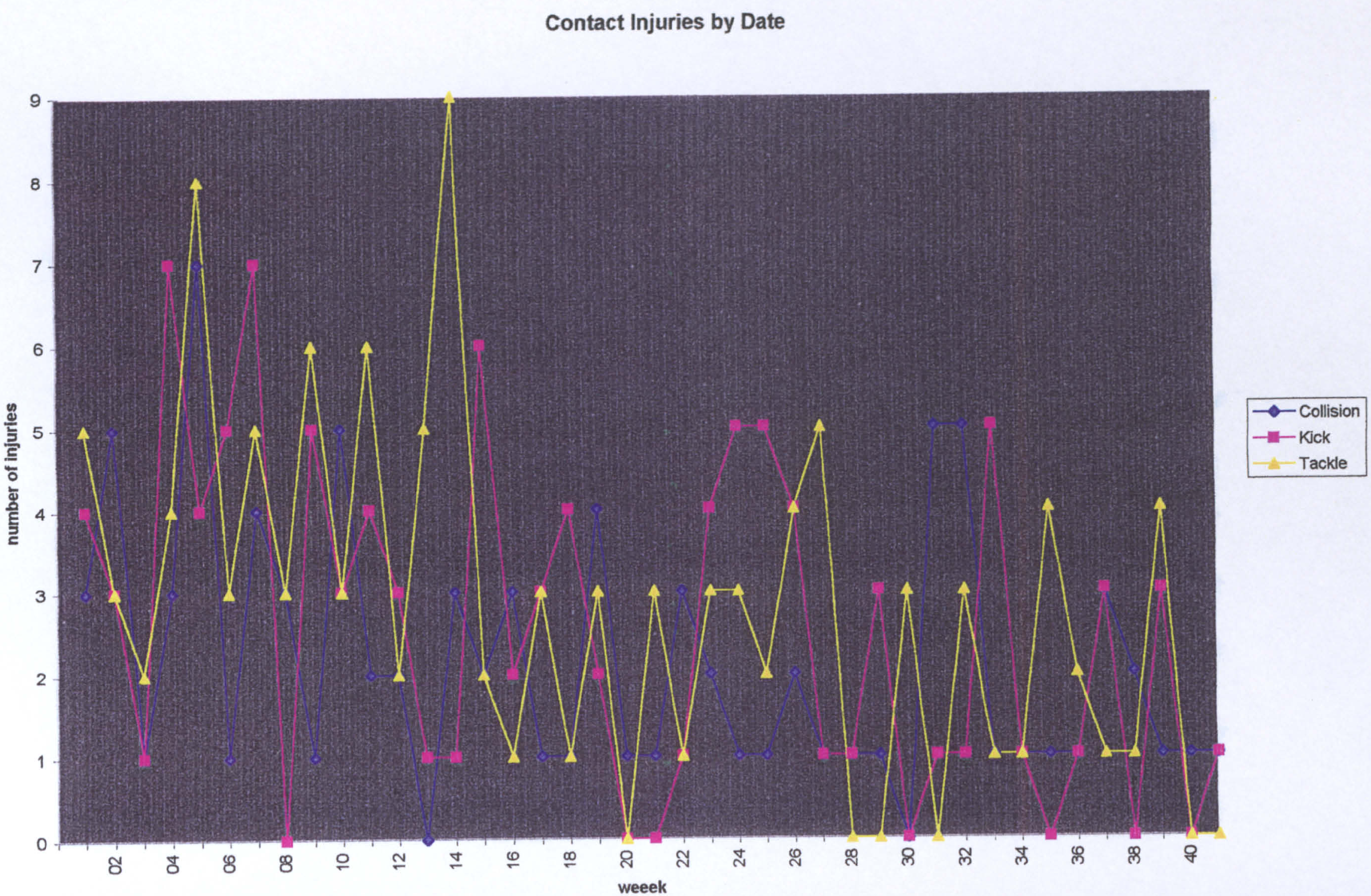

All Injuries by Area Affected
anatomical area
neck
upper leg
upper arm
stomach
shoulder
lower leg
back
lower arm
knee
head
hand
groin
foot
chest
ankle
not specified
2
128
1
10
9
60
37
2
117
24
10
71
31
4
148
23
0
20
40
60
80
100
120
140
160
number of injuries

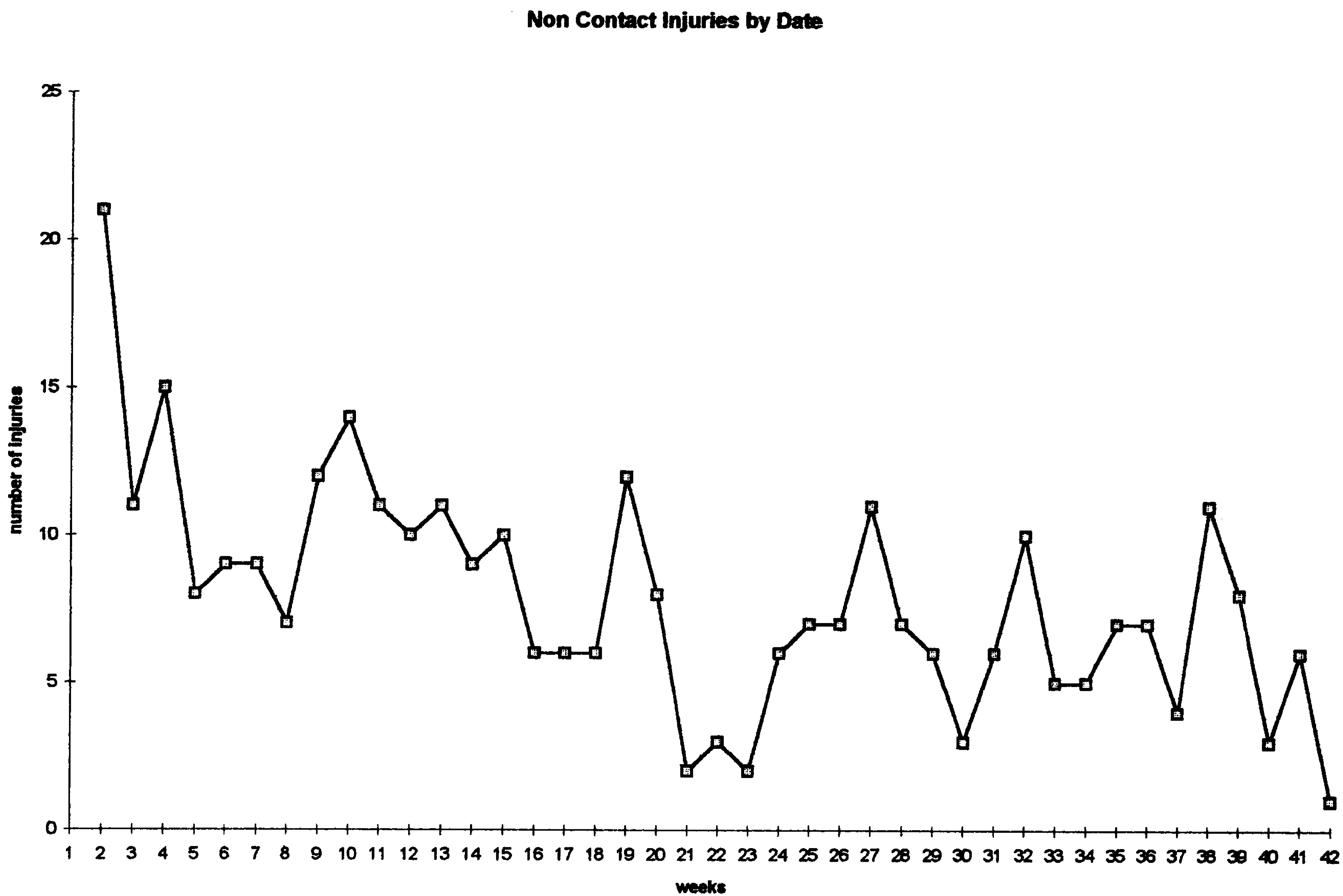
Fig 6.7.



Contact Injuries by Date
number of injuries
0
1
2
3
4
5
6
7
8
9
02
04
06
08
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
weeek
Collision
Kick
Tackle

Fig 6.6

Fig. 6.8.



Sports Injury Study

Fig. 6.9

	Number of Injuries	Percentage
Not Specified	78	11.55%
Bone Injury	34	5.00%
Ligament Pathology	189	27.92%
Muscular Injury	186	27.47%
Soft Tissue Injury	119	17.58%
Tendon Pathology	57	8.42%
Others	14	2.06%
	677	100.00%

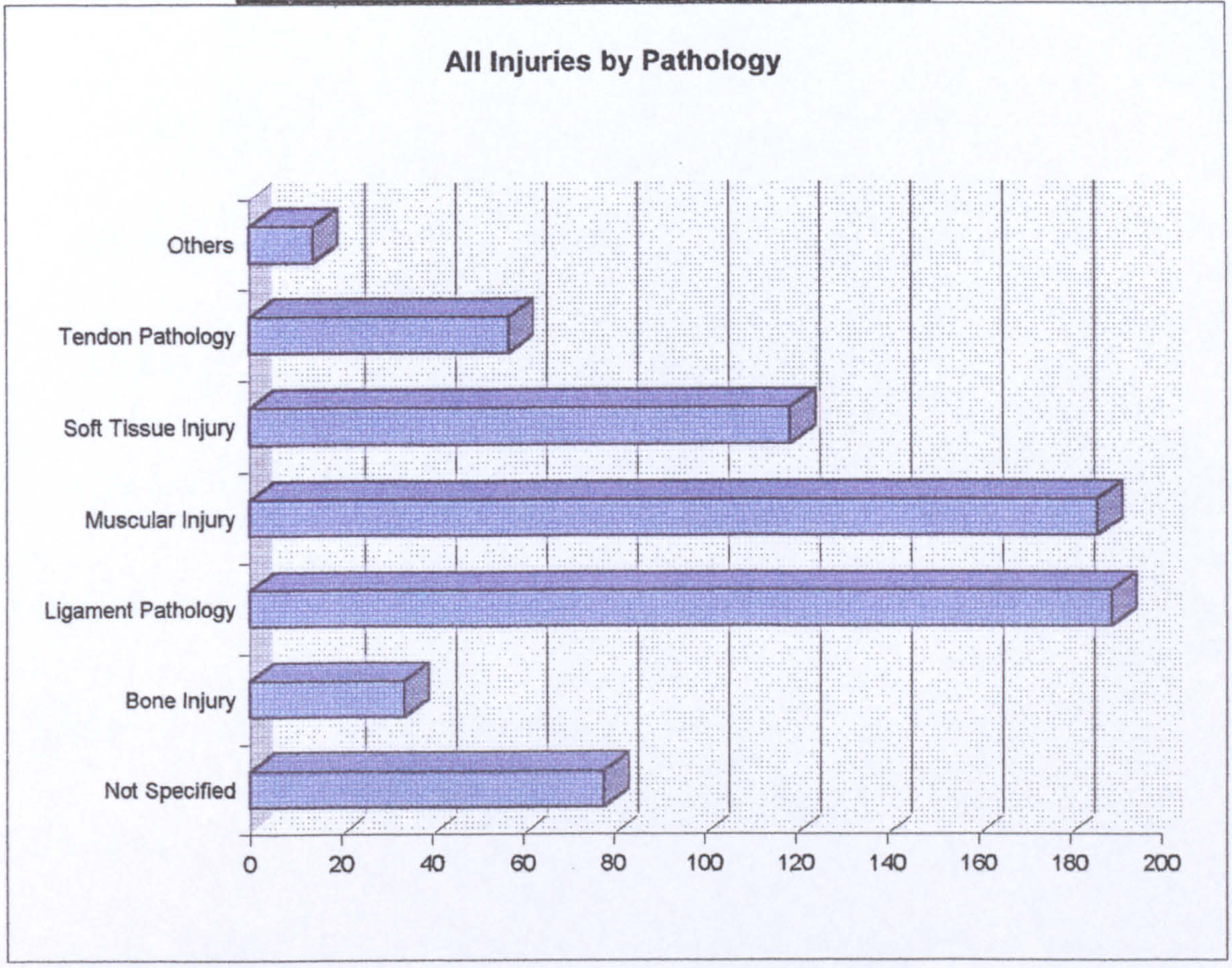
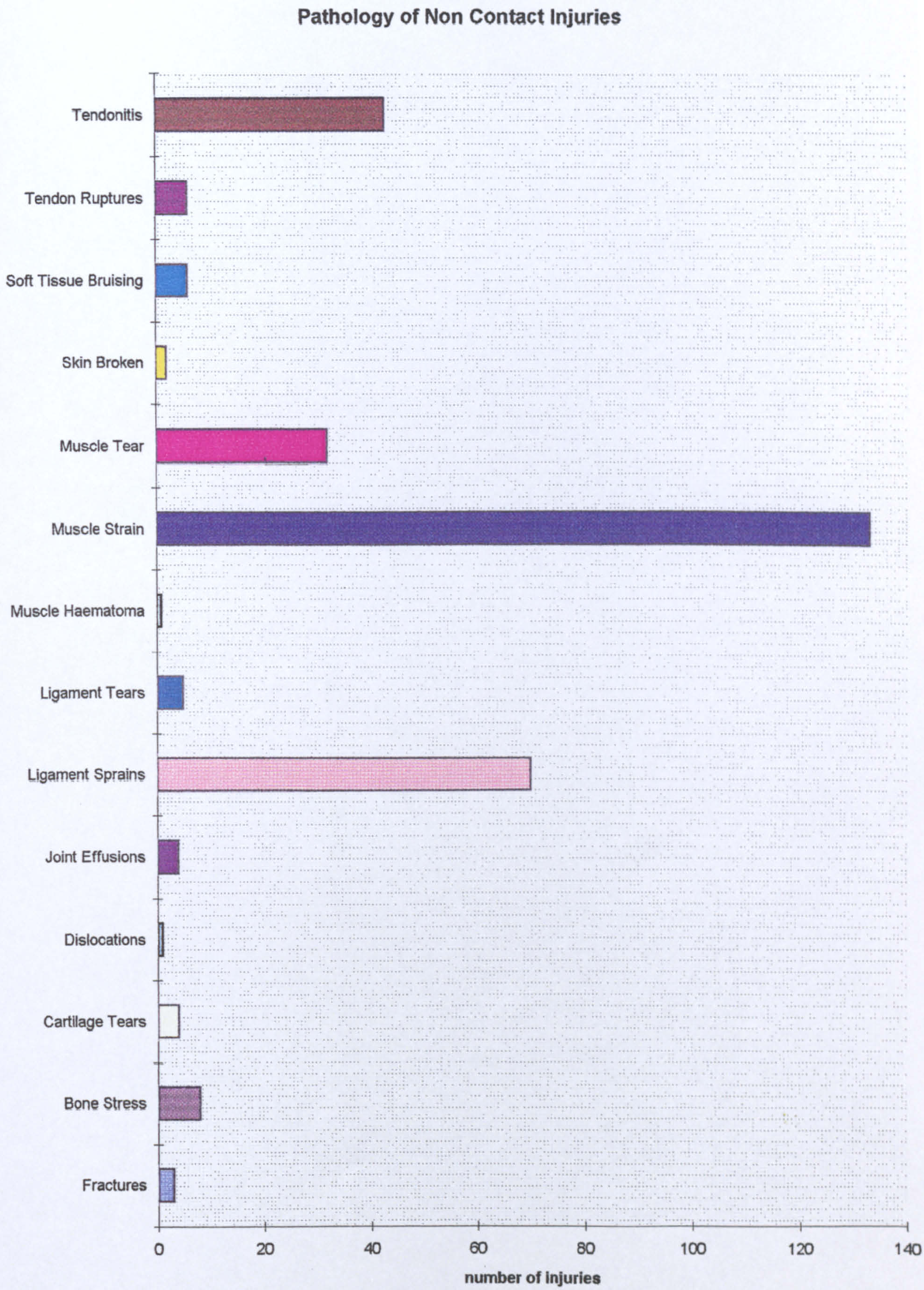


Fig. 6.10



Pathology of Non Contact Injuries
Tendonitis
Tendon Ruptures
Soft Tissue Bruising
Skin Broken
Muscle Tear
Muscle Strain
Muscle Haematoma
Ligament Tears
Ligament Sprains
Joint Effusions
Dislocations
Cartilage Tears
Bone Stress
Fractures
0
20
40
60
80
100
120
140
number of injuries

Fig. 6.11.

	Tackles	Collisions	Kicks
Fractures	9	10	3
Bone Stress	0	1	0
Cartilage Tears	2	0	0
Dislocations	0	1	0
Joint Effusions	0	1	0
Ligament Sprains	64	20	5
Ligament Tears	12	5	2
Muscle Haematoma	3	6	41
Muscle Strain	5	7	0
Muscle Tear	2	0	0
Skin Broken	1	10	7
Soft Tissue Bruising	15	22	46
Tendon Ruptures	1	1	1
Tendonitis	0	1	0
TOTAL	114	85	105

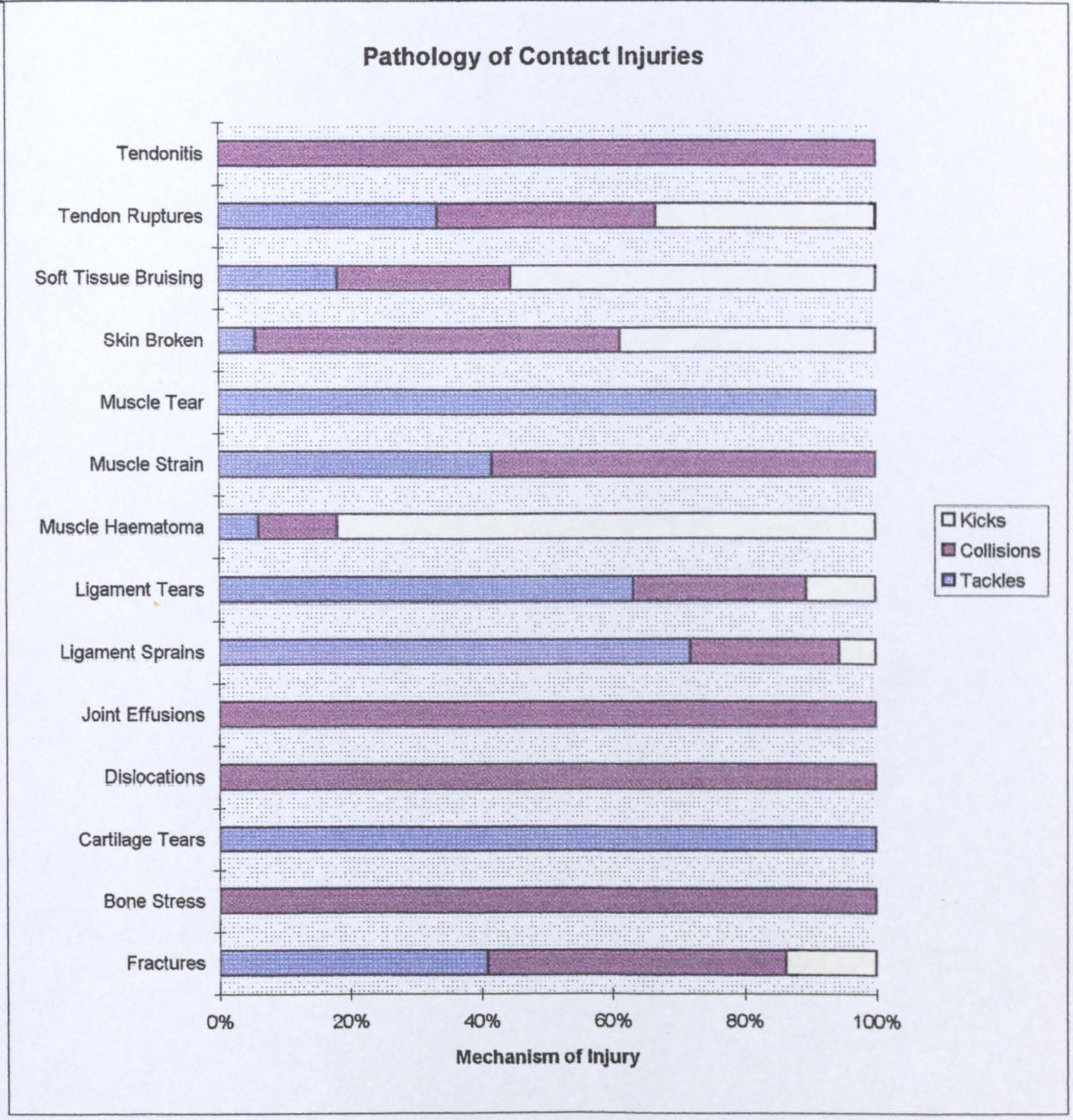


Fig 6.12

Pathology by Mechanism of Contact Injury

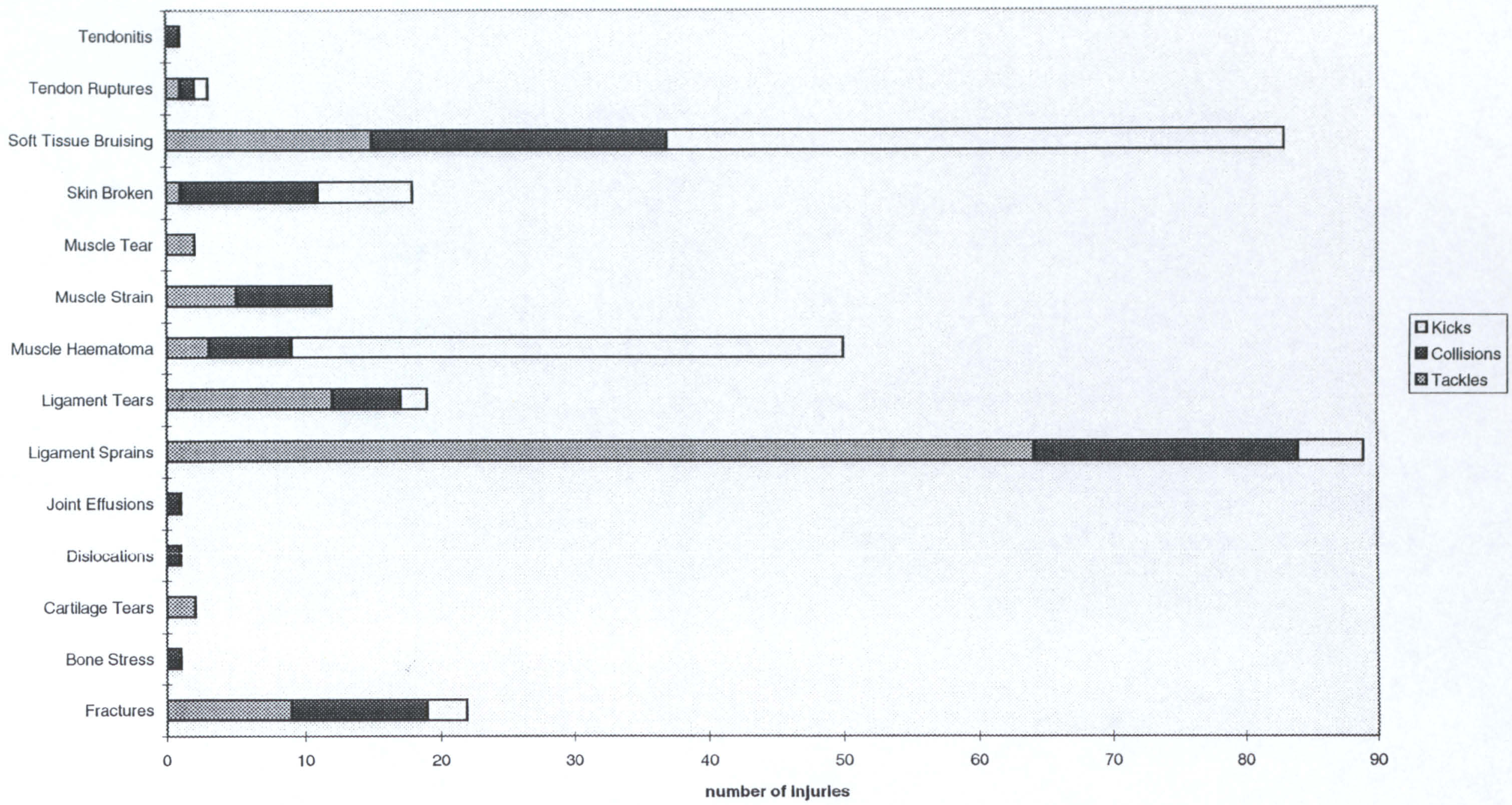
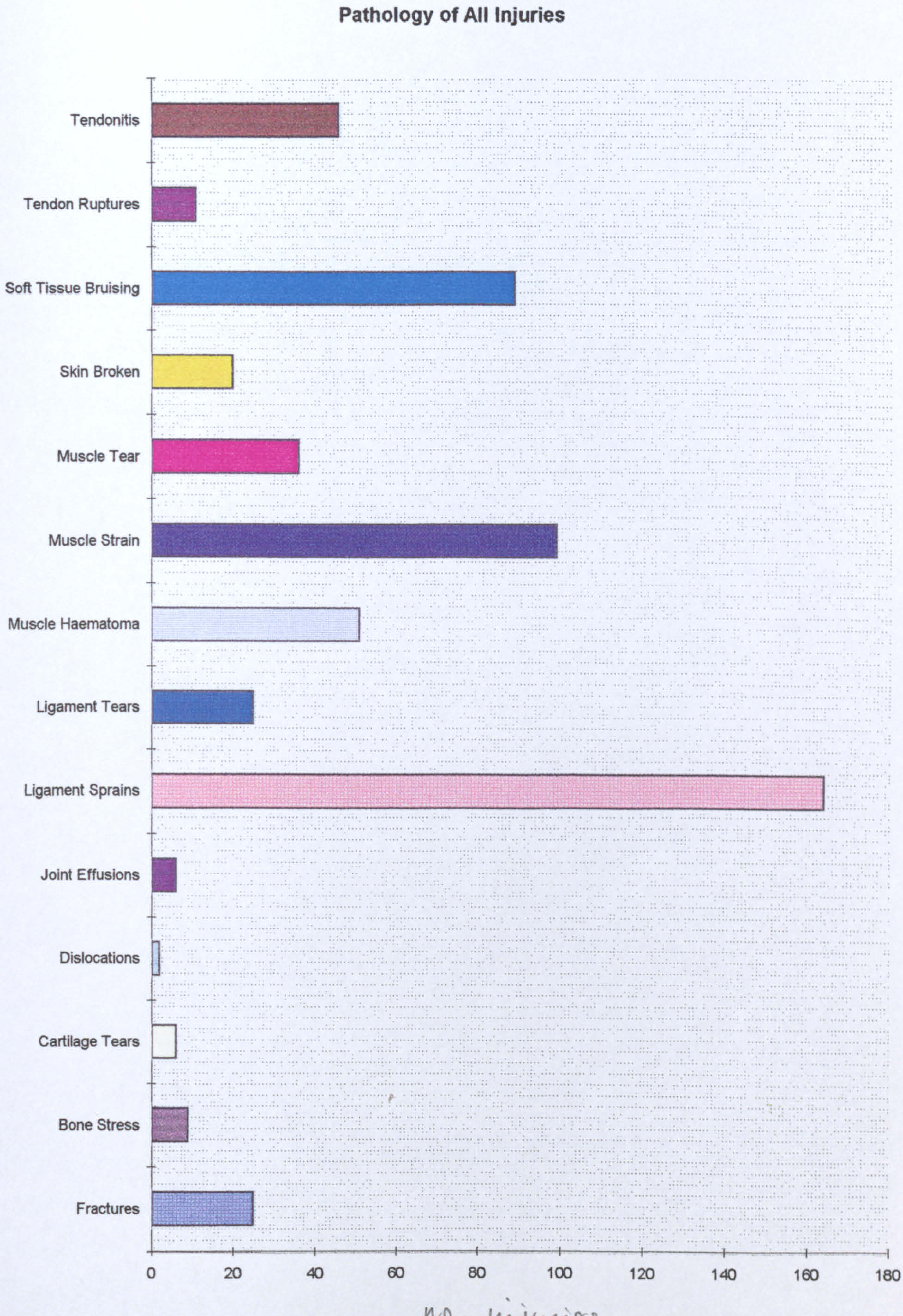


Fig. 6.13.


Pathology of All Injuries
Tendonitis
Tendon Ruptures
Soft Tissue Bruising
Skin Broken
Muscle Tear
Muscle Strain
Muscle Haematoma
Ligament Tears
Ligament Sprains
Joint Effusions
Dislocations
Cartilage Tears
Bone Stress
Fractures
0
20
40
60
80
100
120
140
160
180
no. injuries

7. Injury and Competitive Level

7.1. Introduction

Soccer epidemiology is difficult to interpret because of its retrospective nature and the various ways in which data are collected, whether it be from a clinic, an A & E department or from the field. The data are generally retrospective and differing populations have been studied. This disparity is highlighted when attempting to compare the incidence of injury with the level of competition.

Six Premier teams comprising 108 players were compared with six teams with an identical number of players from the lower divisions. This structure was based on the fact that the most significant step in the competitive soccer ladder is between the Premier and the First Division. The distinction between lower divisions is less clearly defined. The six teams from the lower divisions were predominantly from First Division clubs. The most obvious variable between the different levels of competition is the distinction between full time and part-time clubs. This distinction is now harder to make as a significant number of First Division clubs are full-time or near full-time and those which are part-time, have a sprinkling of full-time players. Thus, the overall training intensity between a maximum part-time club and a full-time club may not be as significant as initially imagined. The majority of full-time clubs still have a relatively light session on a Monday after a weekend match and similarly taper off on Friday prior to the weekend's competition. For most of these full-time clubs, a full training session may only involve a couple of hours in the morning with little input from the senior players in the afternoon. Put in this context, it is clear that the enthusiastic part-time club can come close to the same level of training intensity.

Results

A broad overview was initially taken to assess the total number of injuries during the full season, which totaled 254 for the six Premier clubs and 284 injuries for the six teams from the lower divisions. The mechanism of injury was studied to see whether there was any distinction between non contact injuries and contact injuries (Figure 7.1).

There was no significant difference in the incidence of non contact injuries, with 136 occurring in the Premier group and 130 within the lower divisions. There was, however, a significant difference between the number of contact injuries sustained, with only 116 occurring within the Premier group and a total of 154 in the lower divisions. It was not immediately evident from the superficial assessment of injury mechanism why this should be so. By subdividing contact injuries into collisions, kicks and tackles (Figure7.2), it was evident that there was a similar number of collisions and kicks giving rise to injuries in both groups; however, tackles resulted in injury almost twice as frequently in the lower divisions (50 -v- 27). Of the total 538 injuries assessed, 38 did not specify the mechanism of injury.

7.2. Area Injured by Level of Competition

There was a remarkably similar anatomical distribution of injuries according to the level of competition, with one or two notable exceptions (Figure 7.3). Back injuries were twice as common in the Premier group (19) compared with the lower divisions (9). Interestingly, the incidences of lower leg and groin injuries were not different. The most pronounced difference involved the upper leg which was the most frequently affected area in the Premier group (68), unlike the lower divisions (45). The areas in which the lower divisions predominated were knee injuries (49) compared with only 34 in the Premier divisions. The ankle was also more frequently involved in the lower divisions (65) than the Premier group (51).

7.3. Number of Players Injured.

It was found that 92 Premier players (85%) and 85 players (79%) from the lower divisions were injured during season 1993-94 (Figure 7.4). To avoid spurious reporting it was important to break down the number of injuries in each group and to compare this with the actual number of players injured (Chi-squared=1.533, df=1, p=0.216). This was to exclude multiple injuries occurring among several injury prone individuals which may have biased the comparison. There is no strong evidence that the proportion of players being injured differs for the different levels of competition.

7.4. Injury Recurrence

The level of recurrence was greater amongst the lower divisions, although the consensus of soccer injury epidemiology would suggest that recurrent injuries (which are predominantly non contact injuries) should be more prevalent at higher levels of soccer competition. 16.6% (53) of injuries in the Premier group and 18.7% (42) of injuries in the lower divisions were recurrent (Figure 7.5), although a similar number of players were injured within each group

7.5. Surgery

The surgical requirements between the two levels of competition differed. A total of 19 players required surgery, 11(58%) from the Premier group and 8(42%) from the lower divisions (Figure 7.6). Due to the small numbers involved detailed analysis can be misleading. A similar number of knee, hernia and groin operations were performed in each group. The only significant difference was that two achilles procedures were performed on players from the Premier group and no achilles surgery was undertaken in the lower division group.

7.6. Discussion

Although soccer epidemiology has been extensively studied, a very limited amount of information is available to assess the risk of injury according to the competitive level.

The results from this chapter provide a unique insight into the association between the level of competition in British soccer and injury. There was a remarkably similar overall pattern of injury between the highest professional level and the lower divisions (Chi-squared=1.533, df=1, p=0.216). With a representative sample of 108 players representing each competitive level, it was surprising that the number of <u>non</u> contact injuries did not vary between the two groups (136 and 130). It was anticipated that the higher level of competition would result in an increased number of non contact injuries relating to a higher intensity of training and to increased match frequency (from domestic competition and from European and International duties). This was not found to be the case.

Contact injuries, however, were more frequent in the lower divisions compared to the Premier group (154 and 116 respectively). This may relate to the differing levels of skill, with the less talented group being more susceptible to traumatic injury. This interpretation cannot be qualified and be regarded as subjective as other factors such as violent play may be significant. Engström *et al* (1990) reported that 28% of traumatic injuries were related to violent play. This interpretation would certainly be supported by the analysis of the injury mechanism.

The frequency of injury resulting from tackles was almost twice as common in the lower divisions (50 and 27 respectively) which may relate to poor technique, timing or violent conduct. It was accepted, however, that with this classification of injury mechanism (involving collisions, kick and tackle) there inevitably will be a degree of inter and intra observer variation.

It would be anticipated from the above results that the lower divisions would sustain more ankle injuries due to direct contact from tackling and this was indeed the case (65 and 51 respectively). It was rather surprising that more knee injuries were sustained in the lower divisions (49 and 34 respectively), since, from the preseason assessment, it was evident that there had been more knee surgery performed on the Premier players and one would have anticipated a higher rate of recurrence.

Terminology can be misleading when assessing soccer injury rates. Injury rates corresponding to the level of competition vary depending on the country of origin of each particular study. Most of the pioneering work performed by Ekstrand and Gillquist (1982/83) was on Swedish players involved in senior football. Although this may superficially be interpreted as involving elite players, the 180 players concerned were essentially amateur players involved in the Fourth Division of the Swedish League. Likewise, the American interpretation of an elite player does not necessarily correspond with our understanding of a professional soccer player.

Roaas and Nilsson (1978) reported a higher rate of injury in elite soccer teams compared to the lower divisions. This topic was studied in more detail by Engström (1990). He studied three elite Swedish soccer teams in Stockholm. He chose to study one team from the First Division and two teams from the Second Division. They found a higher incidence of major injury among semi-professional players as compared to professional players.

In contrast to the findings of this study, Engström felt that the elite player was probably more exposed to injury due to the higher training intensity and participation in more games than players in lower divisions. This possibility had been considered by Nilsson and Roaas in 1979. They also suggested that the performance capability of the individual players would be of importance.

Hoy *et al* (1982) assessed soccer injuries presenting to emergency rooms. These injuries were sustained by players playing at an amateur level of competition. Hoy reported that 86% of the players were injured during matches while 9% involved insufficient warm up and the remaining 5% occurred during training.

This emergency room analysis does not provide a suitable comparison for the professional level of competition assessed in this study

Recurrent injuries did not vary significantly between the two levels of competition, but there was an increased rate of recurrence of upper leg injuries in the Premier group. Upper leg injuries involved a spectrum of conditions, principally muscular strains, tears or tendinitis, involving quadriceps, hamstrings and adductor regions. It is clear from the literature that an increased risk of injury in this region may relate to the strength of the player, the degree of hip flexibility (Reilly and Stirling, 1993) and hamstring tightness, which was identified as a possible risk factor in two thirds of senior amateur players by Ekstrand (1982). Upper leg injuries are prone to injury recurrence and the pressure imposed by the competitive level may shorten the period of rehabilitation undertaken by the individual player; however there is no evidence to support this. Strength training increases muscular performance, but the overall effect of the hamstring to quadricep strength ratio (Fowler and Reilly, 1993) remains contentious.

The total number of players injured within each group was comparable. The level of recurrent injury was 18% higher in the lower division group (53 and 42 respectively) although fewer players were injured within this group (85 and 92 respectively). The overall difference in the level of injury recurrence is not dramatic, but it is of concern that collectively between the 216 players, 95 recurrent injuries presented during one season.

In conclusion, contrary to the popular opinion, there was very little variation in the incidence and type of injury according to the level of competition except for contact injuries, with ankle injuries principally as a result of tackling predominating in the lower divisions (65) as compared to the Premier group (51). The Premier group had approximately twice the level of back injury (19) and a higher incidence of upper leg injury (68), when compared with the lower divisions (45). Lower leg and groin injuries did not differ between the groups.

Eighty-five percent of the Premier players and 79% of the players in the lower divisions sustained an injury during this season. The level of injury recurrence, which may reflect on the rehabilitation process, was slightly higher in the lower divisions (18.7%) compared with the Premier group (16.6%). The surgical requirements were very similar, the only significant difference being that two achilles operations were required on players from the Premier group and none on those from the lower divisions.

This study has challenged a few myths and provides an insight into the effect of competitive level on injury risk. Future research should attempt to explain why tackling resulted in twice as many contact injuries in the lower divisions, as an improved understanding would clearly facilitate prevention.

Fig 7.1

Injury Mechanism by Competative Level

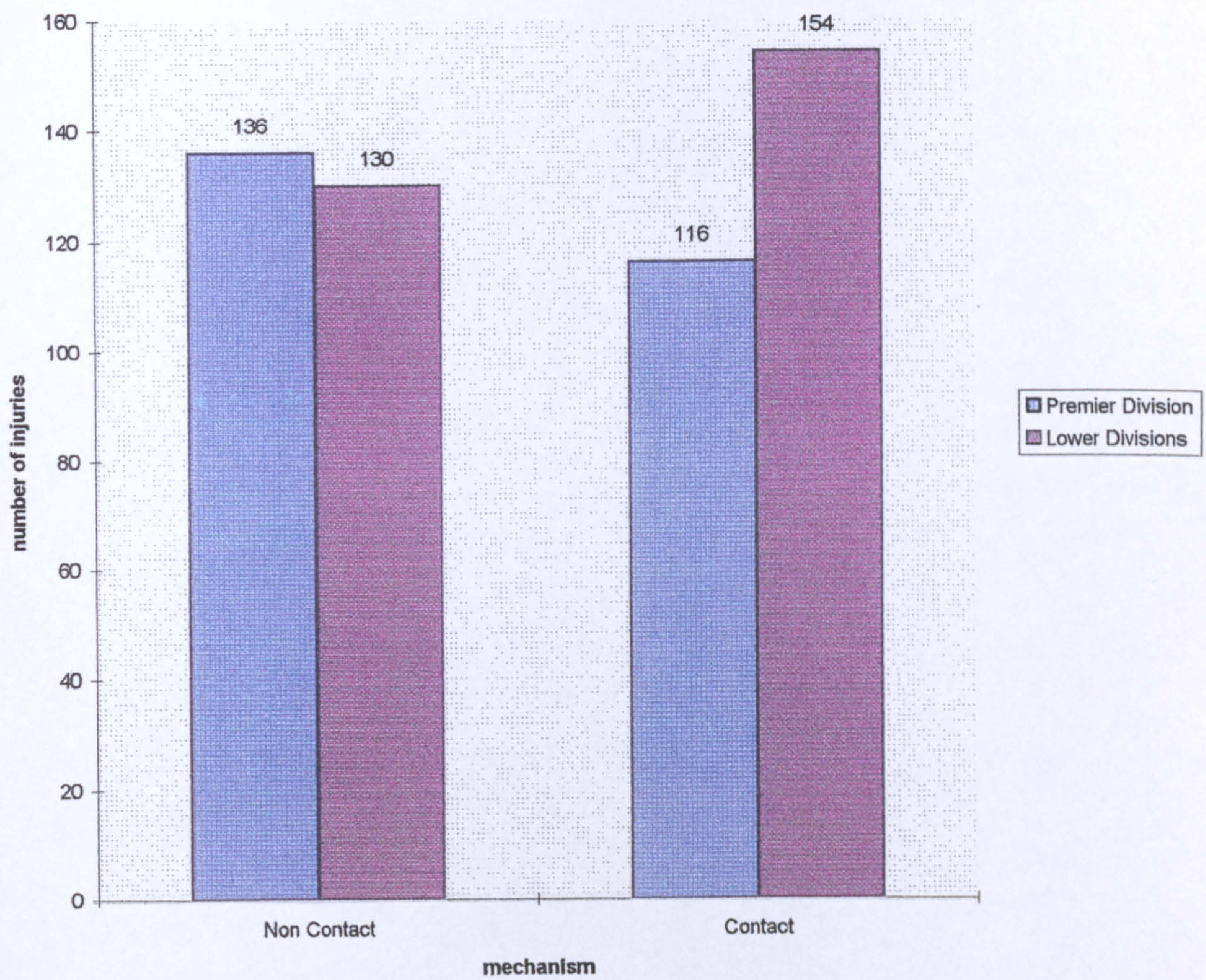
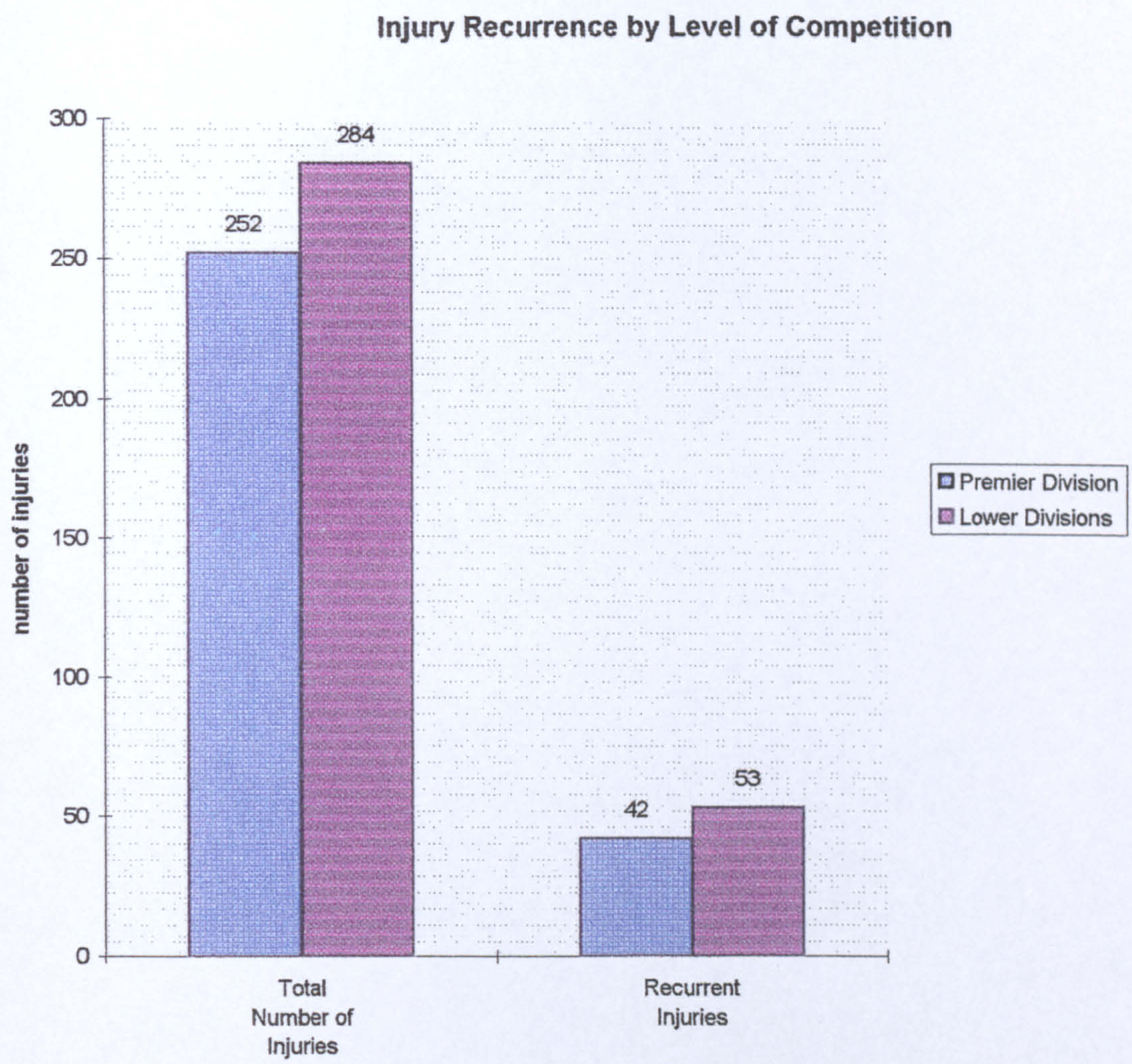
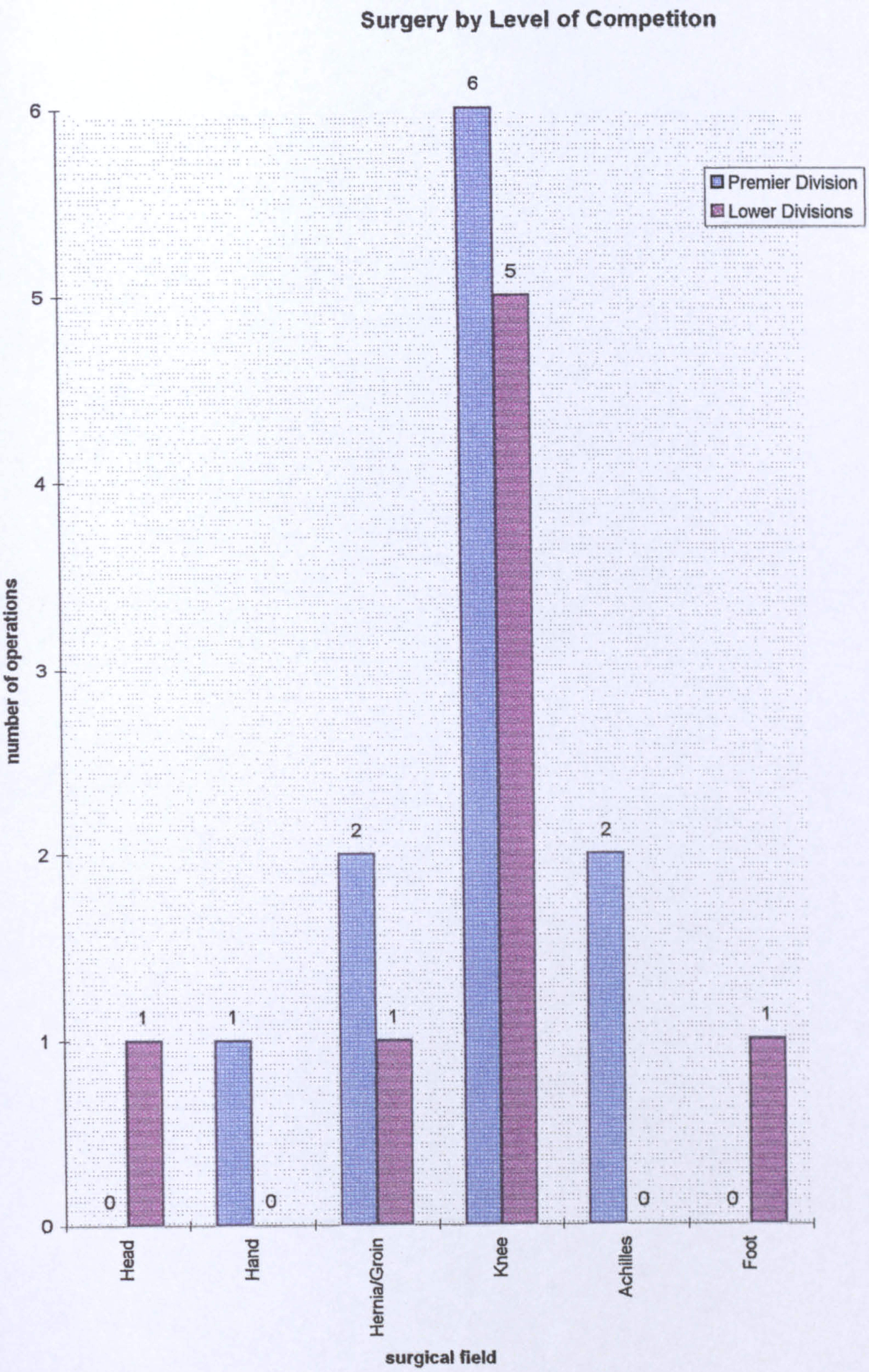


Fig 7.2



Sports Injury Study

Fig 7.3



Sports Injury Study

Fig 7.4.

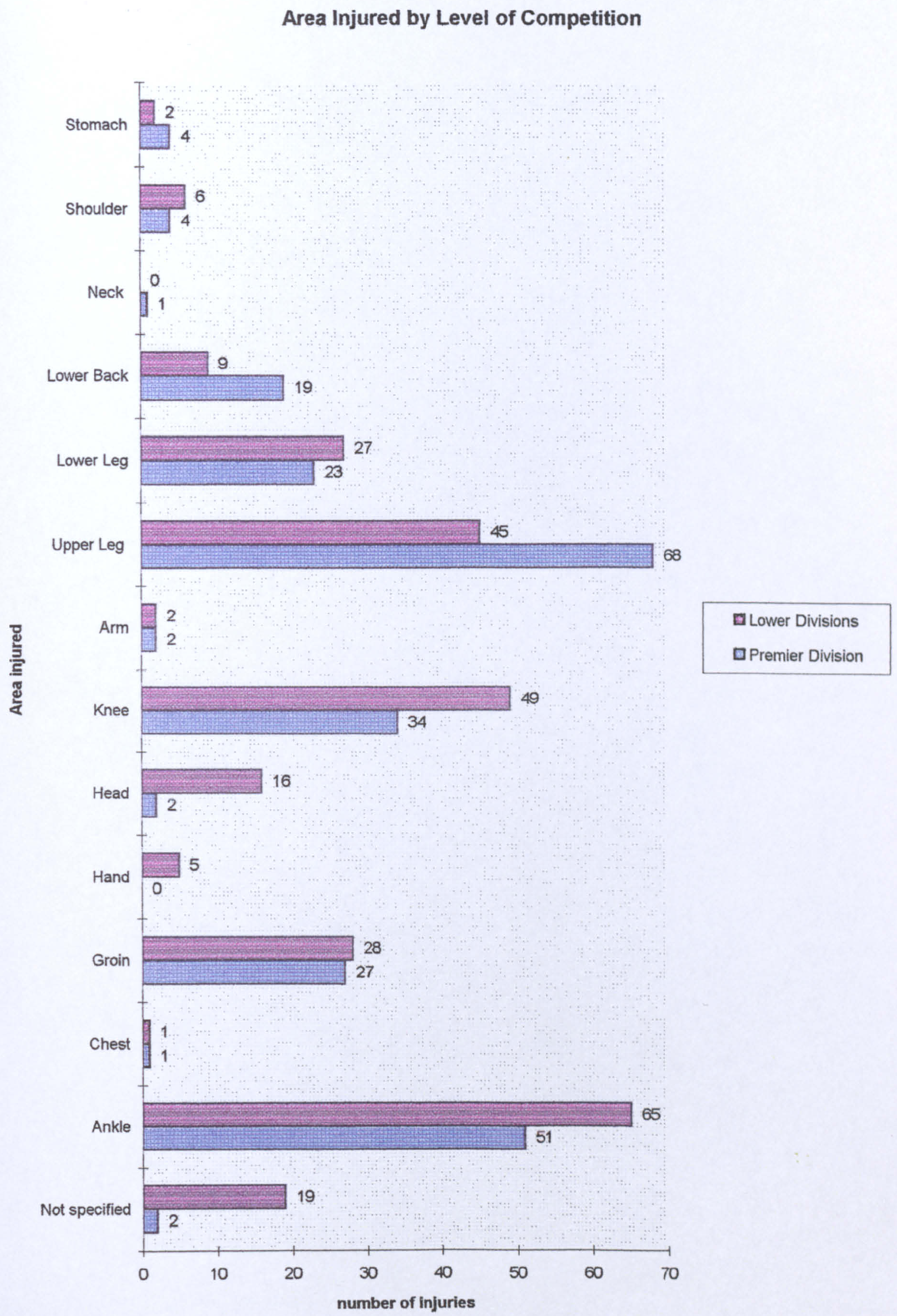

Area Injured by Level of Competition
Stomach
2
4
Shoulder
6
4
Neck
0
1
Lower Back
9
19
Lower Leg
27
23
Upper Leg
45
68
Arm
2
2
Knee
49
34
Head
16
2
Hand
5
0
Groin
28
27
Chest
1
1
Ankle
65
51
Not specified
19
2
Area injured
0
10
20
30
40
50
60
70
number of injuries
Lower Divisions
Premier Division

Fig 7.5

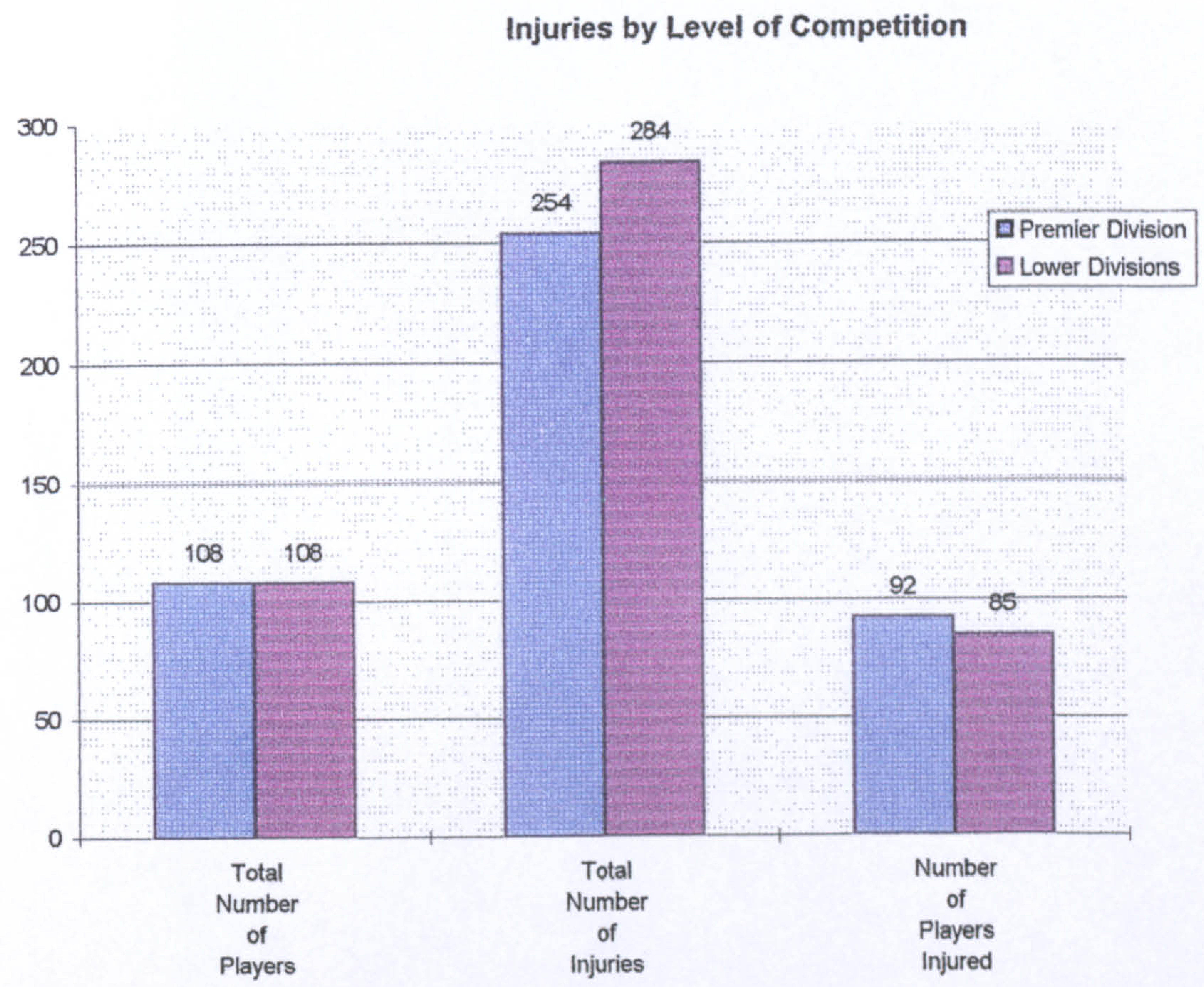
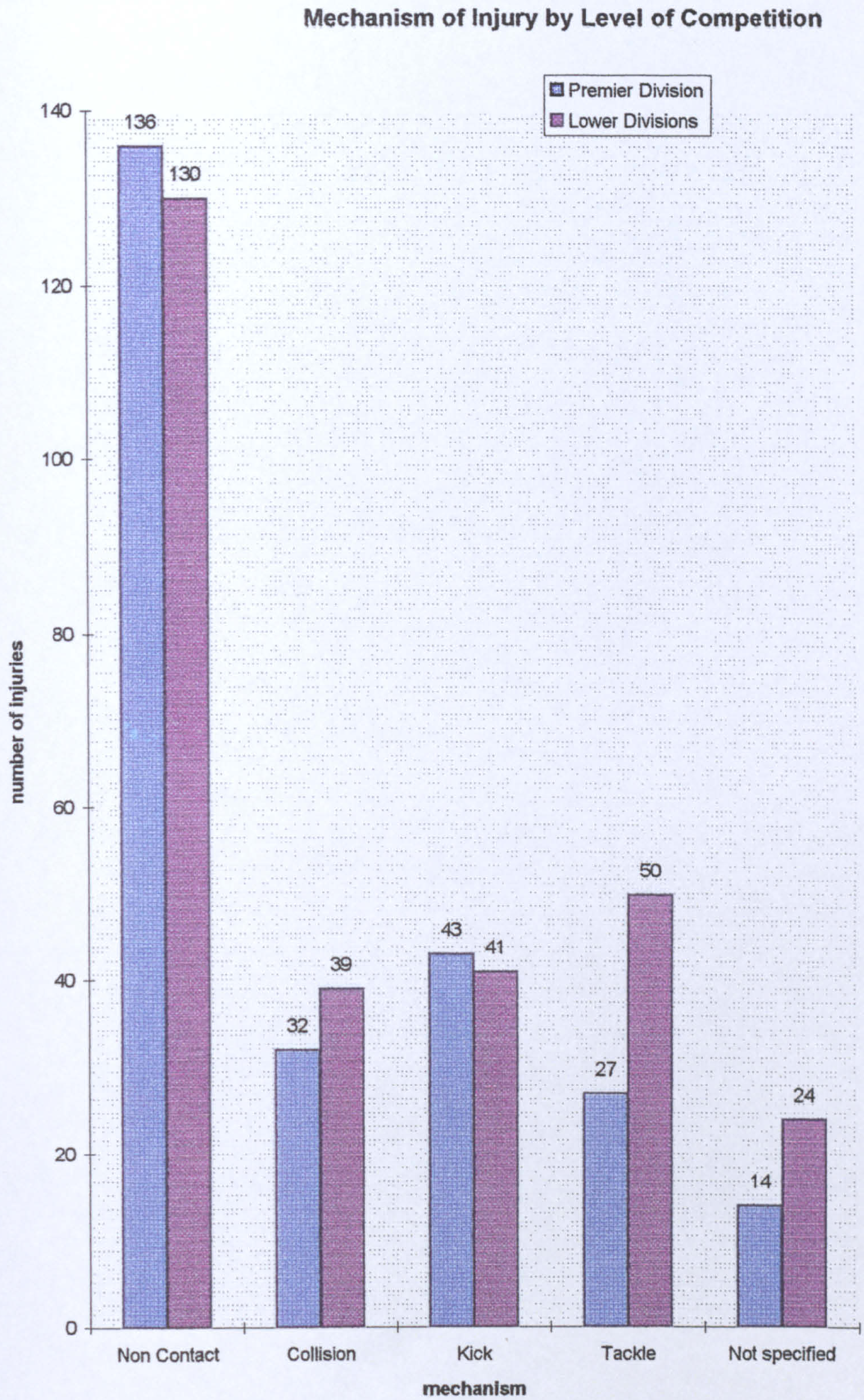

Injuries by Level of Competition
300
250
200
150
100
50
0
284
254
108
108
92
85
Premier Division
Lower Divisions
Total Number of Players
Total Number of Injuries
Number of Players Injured

Fig 7.6



Mechanism of Injury by Level of Competition
Premier Division
Lower Divisions
number of injuries
140
120
100
80
60
40
20
0
136
130
32
39
43
41
27
50
14
24
Non Contact
Collision
Kick
Tackle
Not specified
mechanism

8. Results - Comparison of Match and Training Injuries

8.1. Introduction

An in depth understanding of soccer injury aetiology is essential if further injury is to be avoided. It is clearly important to study the mechanism of injury, the sites involved and the associated pathologies in detail. It is crucial to identify the activities which frequently give rise to injury so that preventative measures can be appropriately targeted. In this chapter match and training injuries will be studied in detail.

8.2. Match and In Season Training Injuries

Match injuries clearly account for the majority of soccer injuries at this level (77%). The remaining 23% of injuries occurred during training sessions (Figure 8.1a). Only 72% (489) of all injuries reported specified whether the injury arose specifically during a competitive match or training session.

8.3. Match Injuries and Substitution

Since the majority of injuries occurred during matches (77%), it is important to assess whether the player was substituted immediately to receive medical attention or whether they chose to complete the competitive match. Surprisingly 54% (203) of the match injuries did not require immediate substitution (Figure 8.1b). Only 46% (174) of the players injured during play were substituted. These statistics may reflect principally on the medical management of match injuries as opposed to their severity, as all reported injuries were significant enough to prevent the individual from participating in the following training sessions or match.

The mechanism of injury occurring during competitive matches was then analysed in detail (Figure 8.2). The appropriate chart illustrates the mechanism of injury.

Non contact injuries accounted for 36% of injuries. The onset of such overuse and overload injuries is often gradual and a full appreciation of the extent of injury may not be evident until after the game's completion. The remaining 64% of competitive match injuries in this category were a result of contact. The aetiology of these contact injuries was evenly shared between collisions (20%), tackling (21%) and kicks (23%). It is unclear why players chose to complete competitive games even when injured, as this may well have been detrimental to their overall injury status.

8.4. Hospital Referral by Injury Cause

Approximately 1 in 10 injuries (11%) required hospital referral. As noted, the majority of injuries (77%) occurred during matches and 12% (46) of these competitive injuries required hospital assessment and treatment. In contrast, not only were training injuries less frequent (23%), but a smaller percentage (6%) required hospital assessment (Figure 8.3).

8.5. Match Injuries Requiring Hospital Referral

It is important to appreciate the mechanism of injury requiring hospital treatment as this group represents the more serious acute injuries, although it is recognised that some of the more benign injuries can present greater problems regarding chronicity. Since 12% of match injuries required hospital referral, it was important to identify the most vulnerable anatomical regions and the injury mechanism. As illustrated (Figure 8.4), the majority of match injuries requiring hospital referral were the result of direct contact. The knee was most frequently responsible (10), although 7 non contact knee injuries also required hospital referral. Eight ankle injuries required hospital treatment after direct contact. No non contact ankle injuries required hospital assessment, although this was a common site and mechanism of injury. All head injuries requiring hospital assessment were the result of contact. Ten players required hospital assessment for head injuries; this number did include some facial injuries. Three non contact groin injuries also required hospital treatment.

Discussion

Match injuries accounted for 77% of the injuries as detailed and this finding is consistent with the findings of Professor K. MacPherson one decade ago (personal communication). This study performed on behalf of the Football Trust, found that 74.3% of injuries occurred during competitive matches, representing 82.8% of all new injuries. Similarly, Nielsen and Yde (1989) reported that 61% of injuries occurred during competitive matches. Ekstrand and Gillquist (1983c) reported that two thirds of traumatic injuries occurred during competitive matches and that 84% of overuse injuries occurred during practice; Nilsson and Roaas (1978) similarly found 73% of traumatic injuries in youth players occurred during match play.

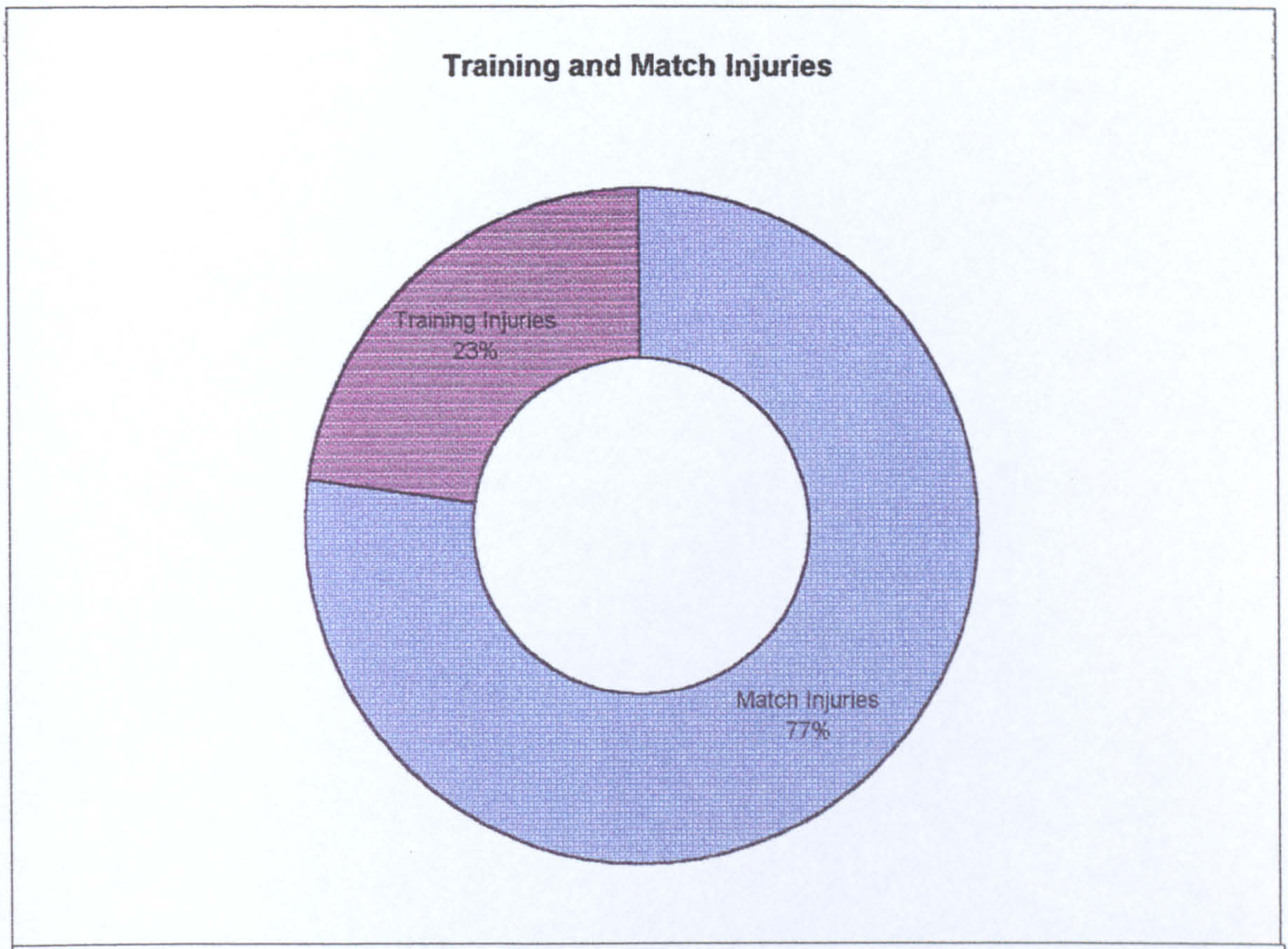
It is surprising to note that 54% of players sustaining match injuries successfully completed the competitive game in which the injury arose. As far as is known, this area has not been assessed in detail and clearly represents an area where medical intervention could prove fruitful. Players may chose to continue to play because of the excitement of competition or due to team loyalty. The pressure for a team position, or the restricted number of substitutes available, may result in players continuing to put themselves at risk. Experimental studies assessing the potential role of free substitution have reduced the number of injuries (Renstrom 1994). This may relate to a reduced incidence of secondary injuries. Ekstrand and Gillquist (1983b) suggested rehabilitation should continue beyond the return to play because as many as two thirds of major injuries are preceded by minor injuries during the preceding three months. This was indeed the finding during the preseason assessment and subsequent follow up of injured players during the first three months of the season (Mackay and Hillis, 1996).

Knee injuries were responsible for a third of all hospital referrals (32%), and of the knee injury group 59% occurred as the result of contact (10). Although knee injuries represent between 18% and 26% of soccer injuries (Sullivan, 1980, Ekstrand, 1982, Albert, 1983, Engström, 1991, Aglietti, 1994), the associated risk of a significant knee injury and the subsequent need for hospital referral is relatively high.

In conclusion, the majority of soccer injuries (77%) occur during matches. Surprisingly, more than one in ten of these injuries required hospital referral. Contact was responsible for the majority of injuries (64%) and knee injuries required the greatest input from hospital based specialists.

Avoidance of contact injuries to the knee must be a priority and all injured players should be removed from the field of play immediately after injury (substituted). Preventative measures would certainly merit further research.

Fig 8.1


Training and Match Injuries
Training Injuries
23%
Match Injuries
77%

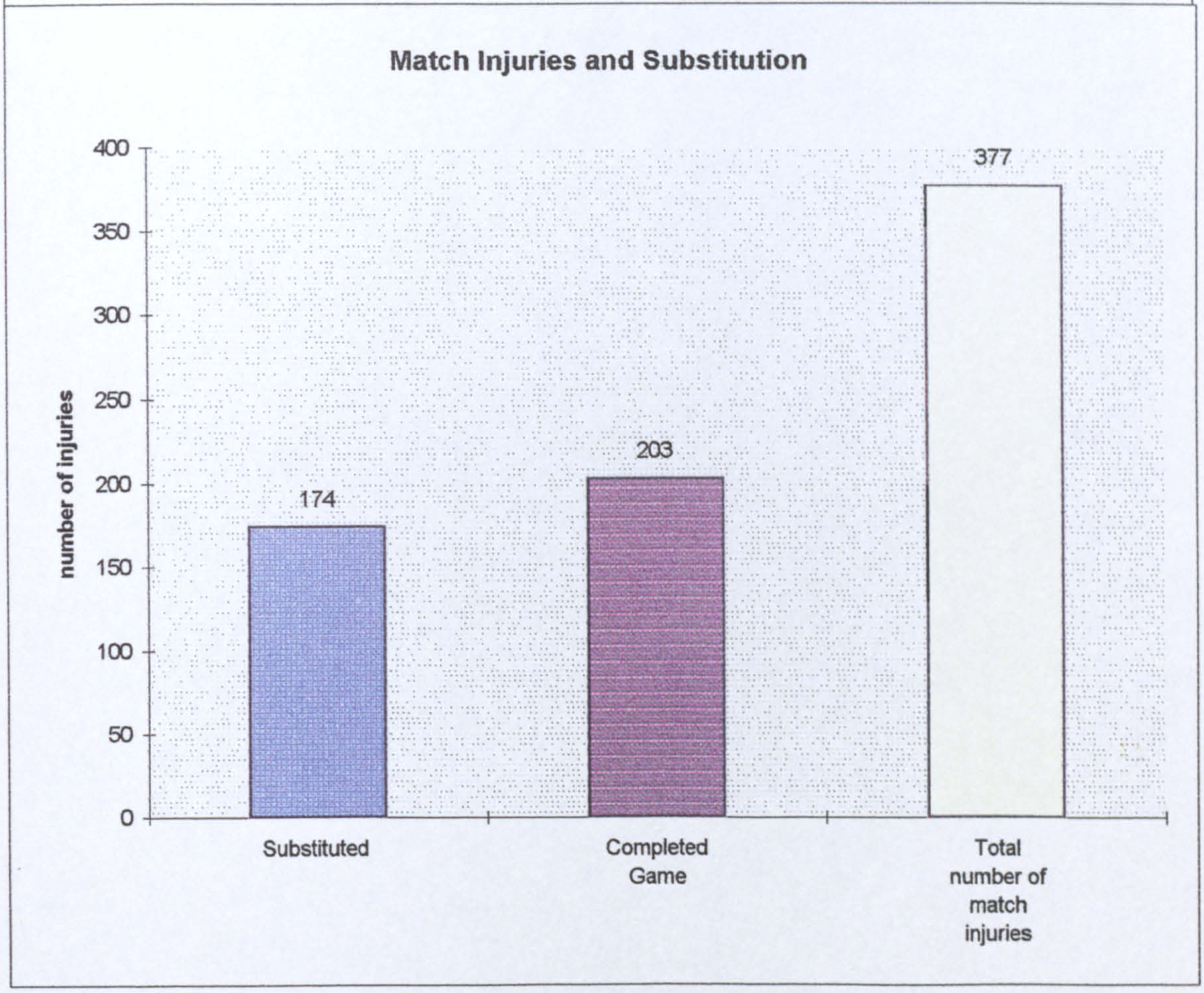

Match Injuries and Substitution
number of injuries
400
350
300
250
200
150
100
50
0
174
203
377
Substituted
Completed Game
Total number of match injuries

fig.8.2

Injured during Match yet Completed Game by Mechanism

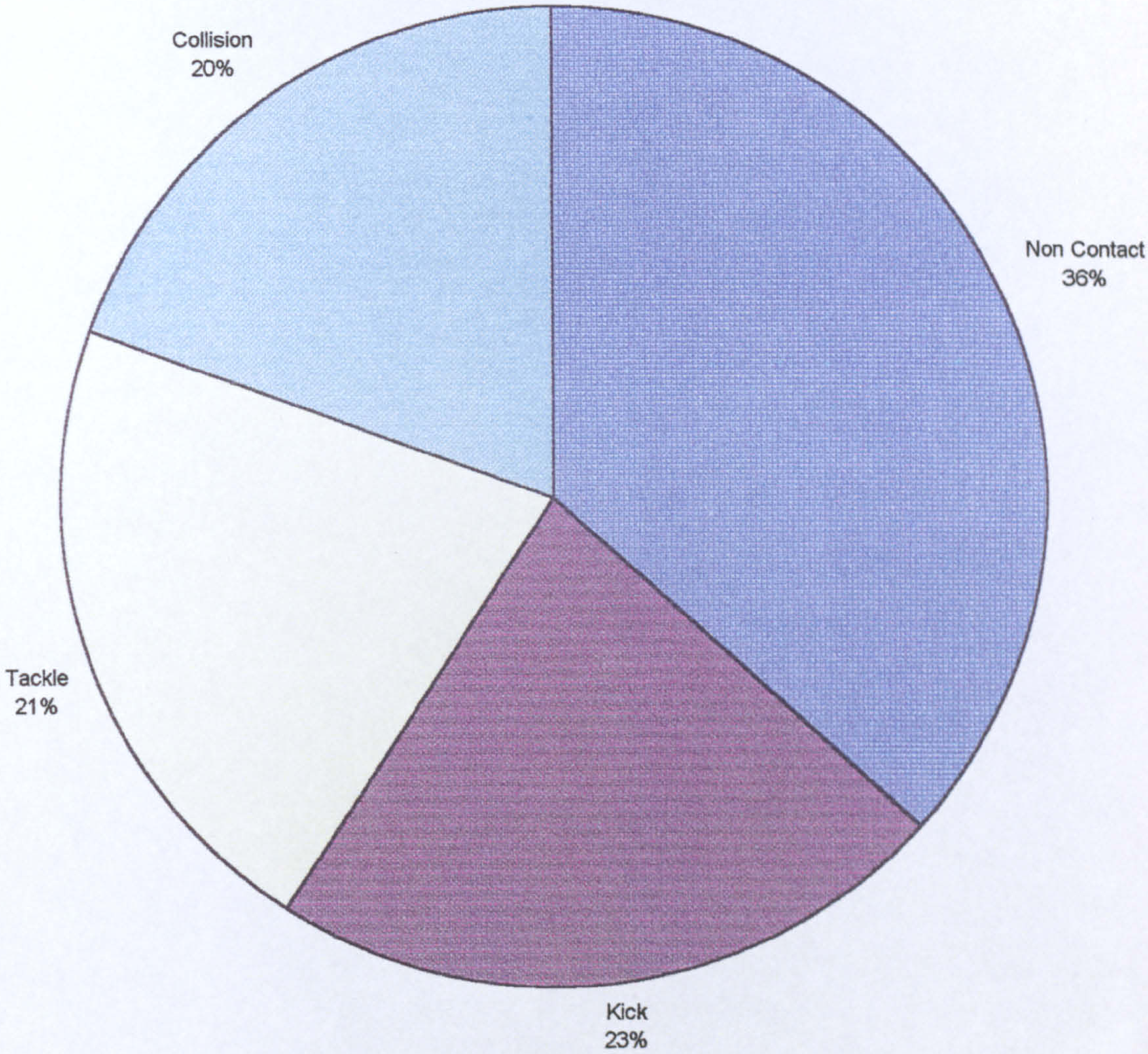


fig 8.3

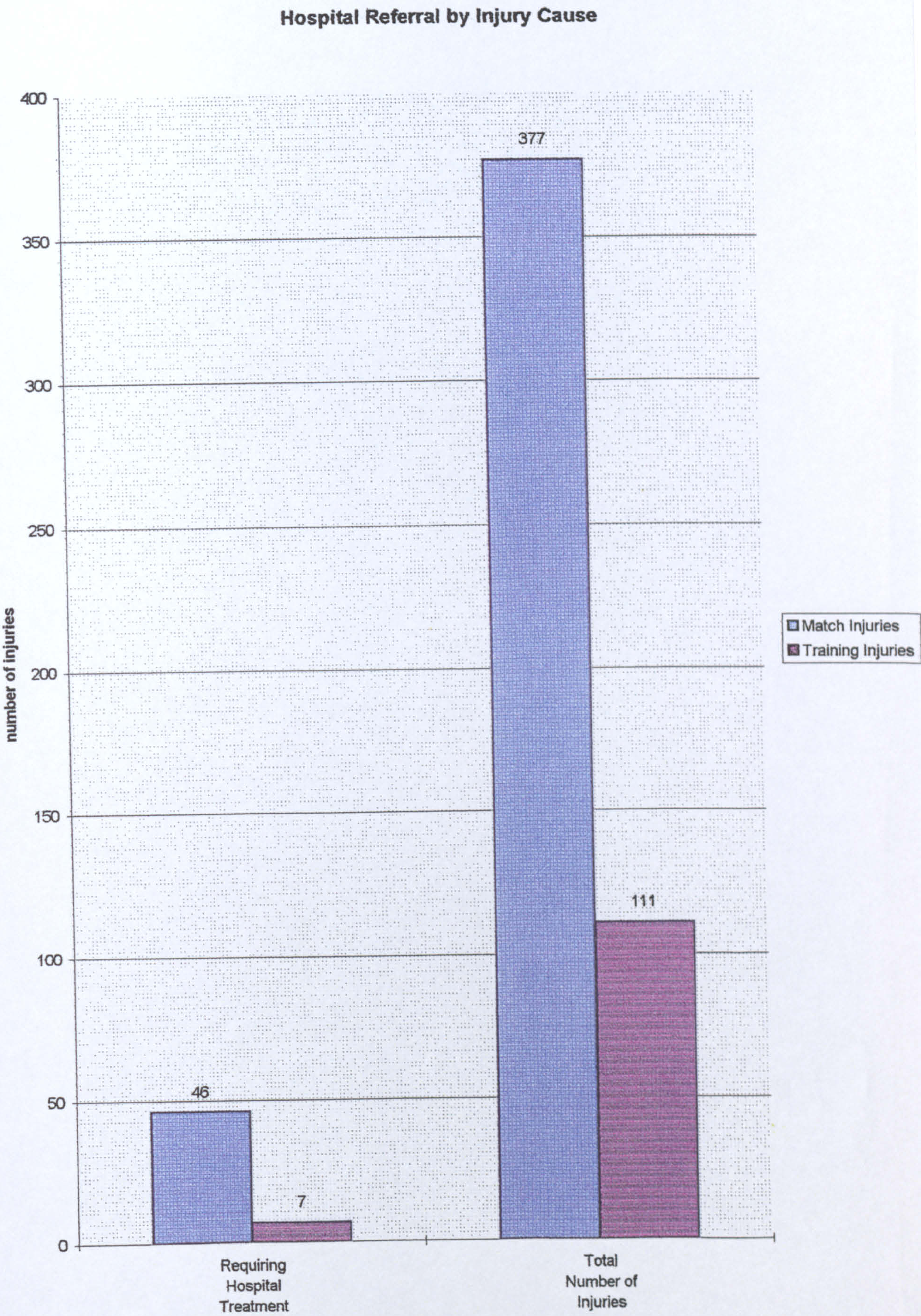
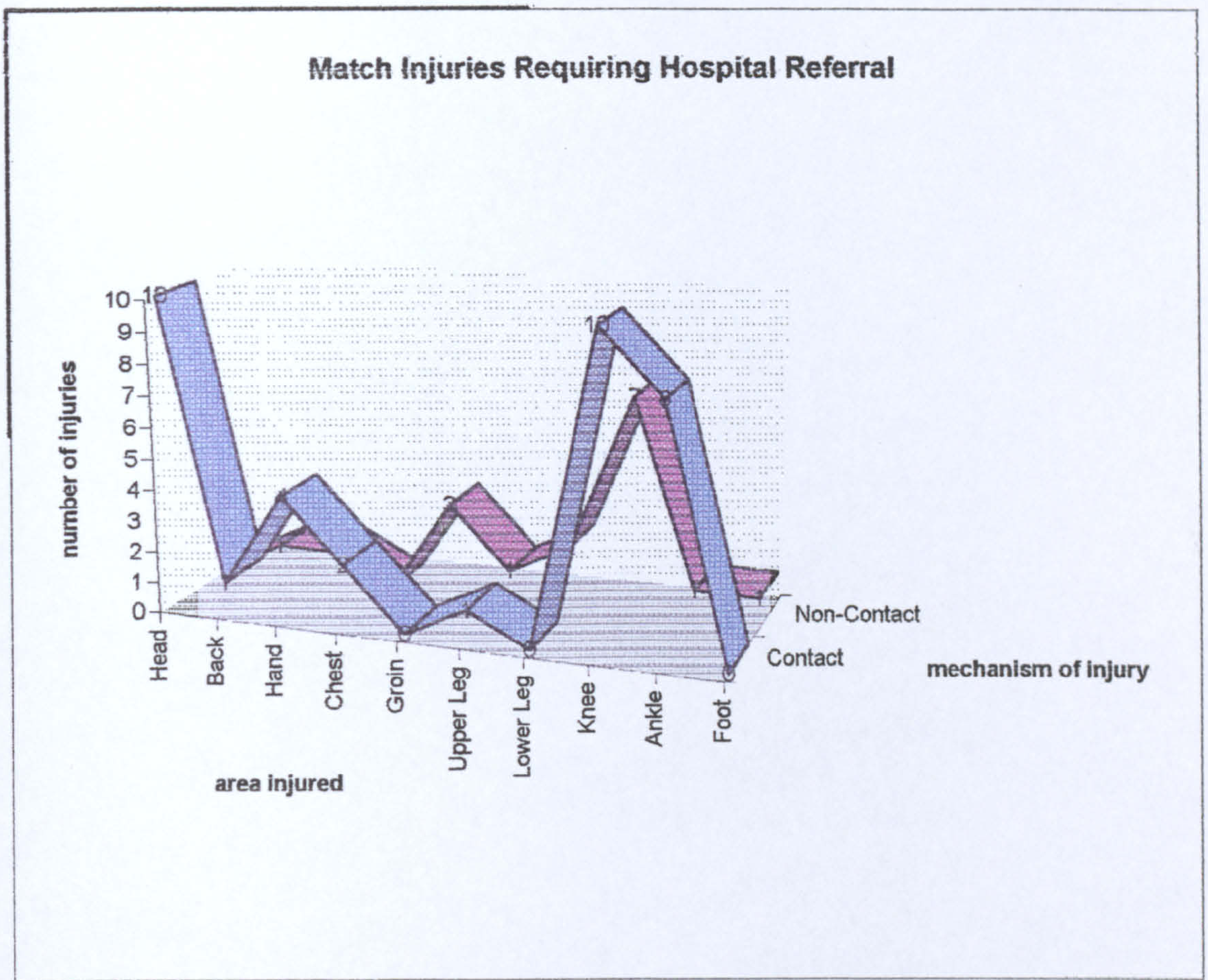
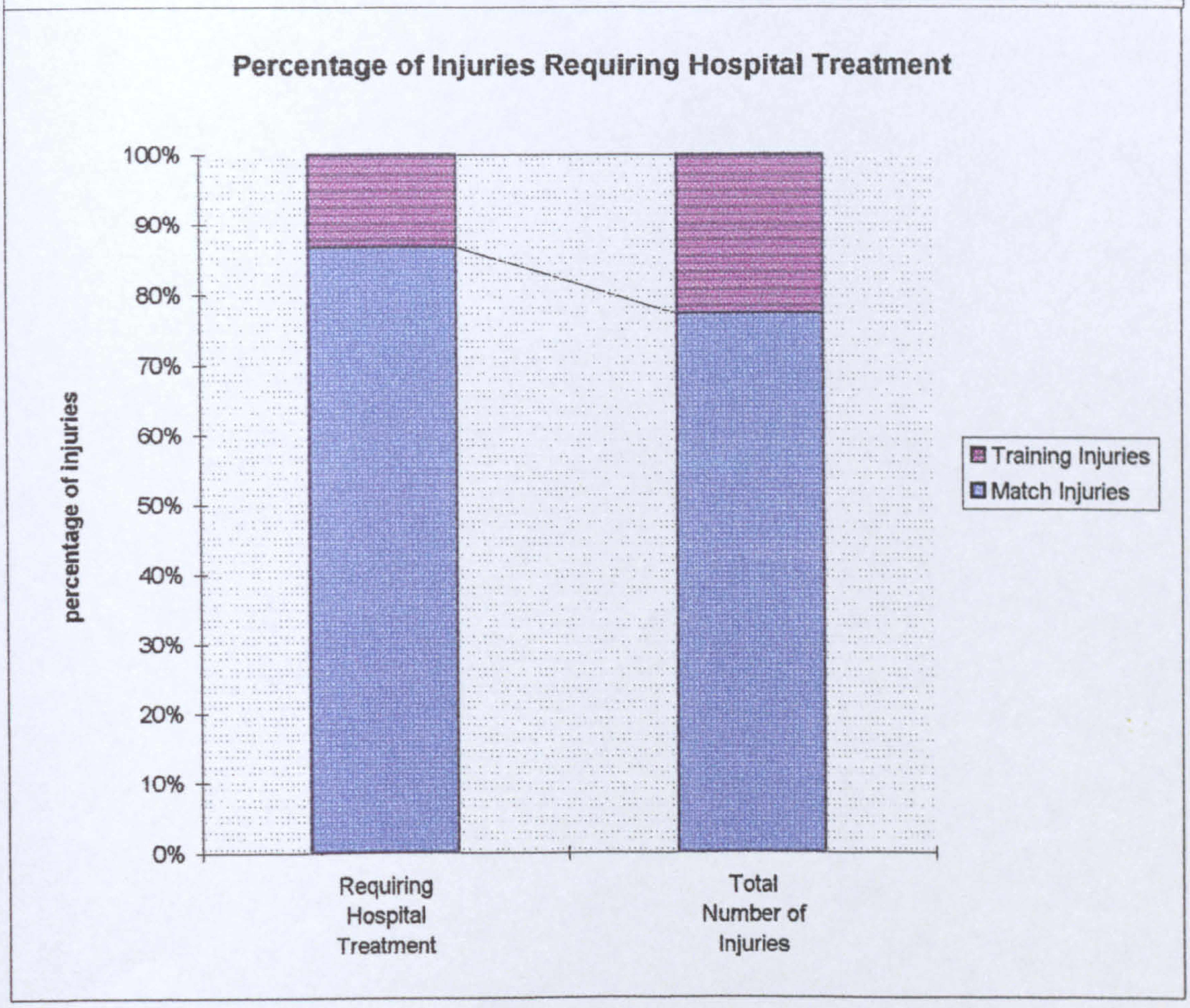

Hospital Referral by Injury Cause
400
350
300
250
200
150
100
50
0
number of injuries
377
111
46
7
Requiring Hospital Treatment
Total Number of Injuries
Match Injuries
Training Injuries

fig.8.4



Match Injuries Requiring Hospital Referral
number of injuries
0
1
2
3
4
5
6
7
8
9
10
Head
Back
Hand
Chest
Groin
Upper Leg
Lower Leg
Knee
Ankle
Foot
area injured
Non-Contact
Contact
mechanism of injury



Percentage of Injuries Requiring Hospital Treatment
percentage of injuries
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Requiring Hospital Treatment
Total Number of Injuries
Training Injuries
Match Injuries

9.0 Results - Comparative Analysis of Frequently Injured Areas

9.1. Introduction

While it is clear from Chapter 6 that almost any part of the body is exposed to injury while playing soccer, several critical areas appear to be especially at risk. Of the 655 injuries for which the area injured was specified the ankle accounted for 23% (148), followed closely by upper leg injuries representing 20% (128), the knee 18% (117), and the groin 11% (71). These frequently injured areas were studied in detail.

9.2. Mechanism of Injury

Injuries arising in the four regions detailed above were assessed independently to establish their aetiological mechanism (Figure 9.1). Surprisingly, non contact injuries predominated in all four regions. Eighty-nine percent of groin injuries were classified as non contact which is remarkably high considering the contact nature of soccer. Only 8% (6) resulted from tackles. Fifty-seven percent (89) of ankle injuries for which the mechanism of injury was specified (156 of 184 injuries), were the result of non contact injury. Contact was responsible for 38% (59) of ankle injuries. Although tackles were a significant cause of ankle morbidity, this still represents a surprisingly small percentage considering the forces involved with tackling.

The mechanism of upper leg injury was very similar to that of the groin region with 75% (93) of injuries occurring without contact. Collisions (9), tackles (4) and kicks (18) were responsible for the remaining upper leg injuries.

The mechanism of knee injury was more diverse than for the other frequently injured regions mentioned above. Although non contact injuries did indeed predominate representing 38% (39), the other contact mechanisms gave rise to the remaining 74%. Tackles represented 30% (31) of the contact knee injuries followed by a approximately half that number of collisions (15) and kicks (13). It is therefore slightly artificial to divide this group into non contact injuries compared with individual mechanisms of contact injury as this dilutes the overall impact of the contact injuries which still represent the main cause of knee pathology.

9.3. Upper Leg Pathology

As detailed above the majority of upper leg injuries occur in soccer without contact. The appropriately titled graph (Figure 9.2), details the resulting pathology as it relates to underlying mechanism of injury. The majority of injuries result in muscle strains 61% (76). The remaining upper leg contact injuries resulted in 18 muscle tears (15%) and 4 ligament sprains (3%). Kicks as would be expected were responsible for soft tissue bruising (13) and several muscular haematomas (6).

9.4. Ankle Pathology by Mechanism

Ankle injuries were the commonest injuries in this study. They represented 27% (184) of all injuries reported. As discussed above, non contact injuries were responsible for 28% (52) of ankle injuries, resulting in ligament sprains (20) and tendinitis (30) (principally involving the achilles tendon).

The majority of ankle sprains resulting from contact were caused by tackles, (38) which also resulted in several cases of soft tissue bruising (6) and four ankle fractures (Figure 9.3). Kicks predominately gave rise to soft tissue bruising around the ankle (15) and a few ligament sprains (4). Collisions rarely gave rise to ankle injuries.

9.5. Knee Pathology by Mechanism of Injury

On assessing the mechanism of the knee injury it was apparent that most were caused by contact (62%); the commonest injury involved ligament sprains (32) resulting mainly from tackles (22). A similar number of knee ligament sprains occurred without contact (20) and this represented most of the non contact injuries to the knee (Figure 9.4). Kicks predominantly resulted in soft tissue bruising as would be expected (8) and the occasional muscle haematoma, ligament sprain and ligament tear. One fracture was also caused by a direct kick. Although tendinitis is rare around the knee it was responsible for 3 non contact injuries. Two tendon ruptures (ACL) were reported and both resulted from non contact injuries.

9.6. Groin Pathology by Mechanism

The majority of groin injuries resulted without any direct contact (Figure 9.5). Muscle strains presented most frequently representing 31% (20) of the groin injuries. Collisions and tackles accounted for the remaining 4 muscle strains. The remaining groin pathologies all resulted from non contact injuries and included muscle tears (12), ligament sprains (10) and tendinitis (9). It is clear from the detailed study of the groin pathology reported that there may have been some diagnostic difficulty and overlap between the groups.

9.7. Recurrent Injuries

Recurrent injuries in general have been studied in detail in Chapter 10. The graph titled "Recurrent Injuries by Area" (Figure 9.6), briefly summarises the problem of injury recurrence as it applies to the more specific areas discussed above. Fifteen percent of ankle injuries (27) give rise to recurrent pathology as did 26% (31) of knee injuries. The upper leg was responsible for a surprisingly high level of injury recurrence, occurring after 19% (31) of upper leg injuries. Although the groin is recognised as being prone to injury recurrence, only 25% (18) of groin injuries recurred during Season 1993-94.

9.8. Discussion

The mechanism of injury was clearly not identical for the four most frequently injured areas (Chi-squared=14.735, df=12, p<0.001).

Ankle Injury

Ankle injuries were prevalent in this study accounting for 27% (184) of all injuries reported. This figure may appear slightly inflated in comparison with other epidemiological studies as it includes tendinitis which accounted for 16% (30) of the ankle injuries reported (or 59% of non contact ankle injuries). Although only four ankle fractures were reported this would appear to be in keeping with European soccer epidemiology.

Two thirds of injuries in soccer occur in the lower limb. Ankle sprains account for the majority of the injuries as reported by several authors. In this study if tendonitis is excluded then 23.5% (154) of injuries involved the ankle. Ekstrand and Tropp (1990) found that the incidence of ankle sprains in male adult soccer players to be slightly lower accounting for between 17 and 20% of all injuries. Nielsen and Yde (1989) reported that ankle injuries were responsible for 36% of lower limb injuries in Danish players, although this data came from soccer tournaments (lasting 5 days) and included all reported injuries.. Hoy *et al* (1982) assessed acute presentation to an Accident and Emergency Department as a result of soccer injuries in Denmark and reported that ankle sprains were the most common injuries. Berger-Vachon *et al* (1986) analysed insurance claims and similarly found that the ankle was the most frequently injured joint, accounting for 20.3% of French claims. Ekstrand and Gillquist (1983) studied 118 senior Swedish players and ankle injuries accounted for 17% of all injuries, all of which were ligament sprains except for one lateral malleolar fracture which was similar to this study.

Interestingly 15% (27) of ankle injuries in this study were reported as recurrent. Rehabilitation after an ankle injury is obviously crucial and the severity of injury may not be appreciated initially. Grana (1990) reported that ankle sprains were associated with a chondral injury in 40 to 50% of cases and osteochondral injury in 6.3%. Strengthening should involve peroneal and anterior compartment exercises and as the strength improves agility and co-ordination activities should be undertaken, using a balancing board, mini trampolene and plyometric exercises (Grana, 1990). Satisfactory results can be expected in 80 to 90% of players after functional treatment. About 10 to 20% of players may develop chronic instability in spite of adequate primary treatment. Functional instability has been shown to relate to peroneal muscle weakness (Tropp, 1985).

In this study no ankle injuries required surgical repair. Of the 13 prospective randomised studies on surgical repair after ankle ligament disruption, five found no significant benefit and four studies concluded that conservative treatment was better than surgical intervention. After surgery, 4% of surgical cases were infected and 7% had associated sensory loss. Functional treatment is therefore the quickest and most effective way to ensure rapid return to play. Delayed or secondary repair gives as good a result as primary repair. Functional rehabilitation should focus on peroneal training (Grana, 1990). Approximately 50% of patients with chronic functional instability of the ankle will regain satisfactory function with stability after 12 weeks of appropriate rehabilitation (Karlsson *et al*, 1991).

Prophylactic ankle strapping has been shown to be effective in the prevention of ankle injuries. It is most effective in players who have sustained repeated ankle sprains and have residual joint laxity. The objective of effective taping should be to limit inversion primarily. The effectiveness of these measures was demonstrated by Ekstrand and

Gillquist (1983). Decreased ankle flexibility may also contribute to recurrent sprains. (Hattori *et al,* 1986).

In conclusion, 57% of ankle injuries in Scottish football are as a result of non contact; and a large percentage of these could be prevented. Appropriate rehabilitation, peroneal strengthening and gentle stretching to maintain an adequate range of motion, as well as an appropriate use of taping should be effective. The majority of contact injuries were due to tackles and more detailed assessment is required to address issues such as playing surface, footwear, surface friction and violent play.

Knee Injury

Knee injuries accounted for 18% (117) of all injuries reported. Similar incidences have been reported by Albert (1983) and Nielsen and Yde (1989) who also found that knee injuries accounted for 18% of all injuries, while Ekstrand and Gillquist (1983) found this figure to be slightly higher at 20%. Although slightly less frequent than ankle injuries, knee injuries can be expected to give rise to greater concern, as they may result in considerable chronic disability or even end a player's career (Engström, *et al* 1990).

In this study 74% of knee injuries were the result of contact, which is similar to the findings of Ekstrand and Gillquist (1983) who reported that 69% of all knee injuries were the result of direct trauma and 31% was through overuse. Non contact knee injuries may reflect inadequate rehabilitation after a previous knee injury and persistent instability. Arvidsson *et al* (1980) reported a persistent 20% loss of muscle strength in an affected leg five to ten years after knee surgery. These individuals had resumed sport and believed themselves to be fully rehabilitated. This indicates that rehabilitation after injury should continue even after the individual considers himself fit to resume his playing duties. The demands of jumping, cutting and decelerating in soccer can result in considerable torque being applied to a flexed knee. In this study only two anterior cruciate disruptions were reported. It is unclear whether underlying ligament laxity, possibly in the form of a deficient anterior cruciate ligament, may have contributed to a high incidence of knee injury recurrence. Twenty-six percent of knee injuries (31) were classed as recurrent injuries. This high level of recurrence clearly presents a challenge to the medical team and coach. Careful evaluation of knee function is therefore essential in order to determine if and when a player is ready to resume competition.

Contact injuries gave rise most frequently to ligament sprains (32), the majority resulting from tackles (22). General recommendations can be made to minimise the risk of injury to the knee which includes strengthening, skills training and improved technique especially when cutting and turning or tackling. Because of the severity of anterior cruciate ligament injury, training where possible should be tailored to minimise the risks of such injury. Professor Cerulli (In press) has reported a 10 fold reduction in the incidence of ACL injuries in Italian soccer players after introducing advanced proprioceptive exercises (1.15 to0.15 ACL injuries per season per team). It is important to note that we have a favourable starting point as the incidence of ACL rupture in this study was approximately half the estimated average of one per hundred players per year in senior football. (Ekstrand, 1994).

Groin

The majority of groin injuries (75%) occurred without contact. Muscle strains accounted for 31% of groin injuries although muscle tears, ligament sprains and tendinitis frequently presented. Although relatively insignificant to begin with groin pathology can result in chronic discomfort and limitation. Because of the diagnostic difficulties surrounding groin injury this specific region appears to have been poorly studied in the international literature. Groin injuries have been variously classed as upper leg, thigh, or pelvic injuries. Groin injury demands a high degree of diagnostic acumen as the diagnosis is often clinical and imaging has little to offer. X-rays can provide a base line which will exclude spondylolisthesis and identify a frank spondylolysis. Imaging should also identify an osteitis pubis although this can be clarified by taking a flamingo view. Herniography has been tried and has proved to be of limited value. Nerve entrapment may give rise to groin discomfort and testing with local anaesthetic administration can localise ilioinguinal, genital femoral, obturator and femoral cutaneous nerve entrapment. For groin pain persisting for more than three months a rectal examination is recommended. Through systematic examination it is possible to exclude adductor, pelvic and lower back pathology and through a process of elimination a lower abdominal wall deficiency can be detected.

The syndrome of groin disruption known as Gilmour's groin (1992) has been accepted as the term to describe groin disruption, common within the soccer community, and giving rise to chronic groin pain. Essentially his diagnosis is one of exclusion; his results from surgically reinforcing the posterior inguinal wall and conjoint tendon have allegedly been successful. Although the detailed pathophysiology has been contested, several authors now recommend groin exploration, as the pathophysiology may simply represent a small disruption in the external oblique (Foster and Williams, 1995). Remarkably, in this study almost as many players required groin surgery when compared with knee surgery. At this stage methods of preventing groin disruption remain a matter of speculation. It would seem reasonable from a physiological perspective that abdominal strengthening exercises including the oblique muscles as well as the rectus abdominus and principle hip flexors may help to minimise injury as well as frequent stretching to maintain a physiological range of motion. Continued soccer participation in the presence of groin discomfort may lead to muscle inhibition and further injury. It would also be prudent to recommend an appropriate warm up, before explosive kicking with an associated increase in intra-abdominal pressure, is undertaken.

Upper Leg Pathology

Sixty-one percent of upper leg injuries were the result of muscular strains, the majority occurring without contact. Ekstrand and Gillquist (1983) reported that 14% of injuries involved the upper leg and Engström *et al* (1991) reported a similar figure of

15%. Nielsen and Yde (1989) reported a slightly higher percentage (22%) although this figure included groin injuries.

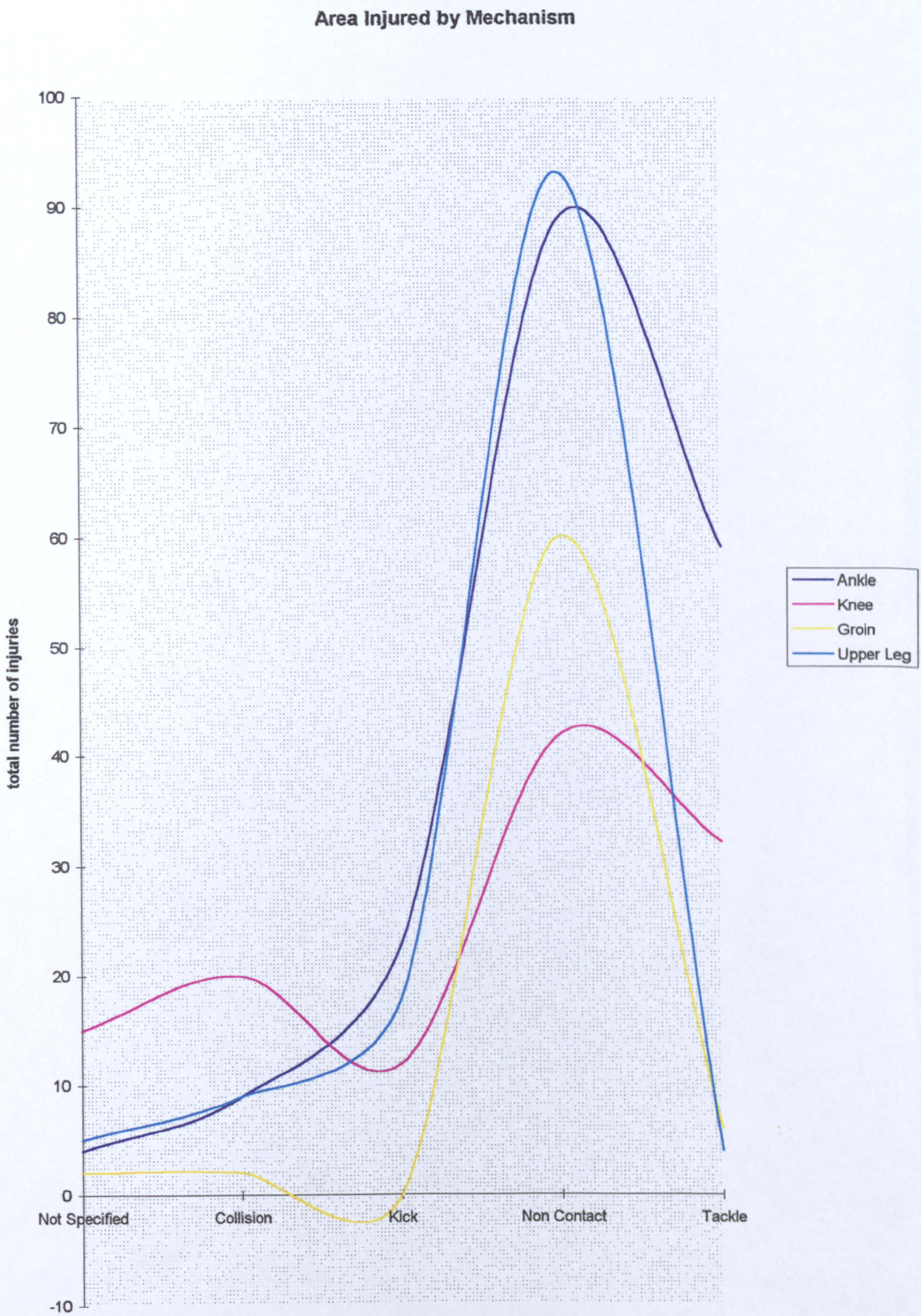
The majority of muscular strains involved the thigh; the avoidability of such injuries was studied by Ekstrand and Gillquist (1983). They found that an adequate warm up followed by stretching was effective. They reported a 75% reduction in the number of musculo-tendinous injuries within the study group compared with a control group. They recommended a stretching programme and it was reported that rectus femoris strains could be reduced by performing an appropriate warm up before kicking the ball.

Treatment is also important to minimise the level of injury recurrence. In this study 19% ofper leg injuries were recurrent which is clearly unacceptible. Treatment should involve a short period of immobilisation, and then mobilisation to avoid atrophy and scarring (Lehto and Jarvin, 1991). In essence first aid should involve elevation, compression and ice to decrease haematoma formation and oedema. Rehabilitation should be gradual and planned (Benazzo, 1989). Before return to play the player should be pain free, have normal strength and have a full range of motion in the affected muscle.

Prevention is the key to the effective practice of Sports Medicine. For upper leg injuries and muscular strains this should involve appropriate conditioning and training to improve technique, strength and coordination. The quadriceps/hamstring balance is recognised as being important, although their interpretation is open to debate.

In conclusion, this comparative analysis of frequently injured areas should help to focus our attempts to prevent soccer injury and its recurrence and puts this study's findings into context.

Fig 9.1



Area Injured by Mechanism
100
90
80
70
60
50
40
30
20
10
0
-10
total number of injuries
Not Specified
Collision
Kick
Non Contact
Tackle
Ankle
Knee
Groin
Upper Leg

Fig 9.2

	Collision	Kicks	Tackle	Non Contact	Recurrent Pathology
Fractures	0	0	0	0	0
Bone Stress	0	0	0	0	0
Cartilage Tears	0	0	0	0	0
Dislocations	0	0	0	0	0
Joint Effusions	0	0	0	0	0
Ligament Sprains	0	0	0	4	1
Ligament Tears	0	0	0	0	0
Muscle Haematoma	4	6	1	0	0
Muscle Strain	3	0	2	71	18
Muscle Tear	0	0	0	18	5
Skin Broken	2	0	0	0	0
Soft Tissue Bruising	0	13	1	0	0
Tendon Ruptures	0	0	0	0	0
Tendonitis	0	0	0	0	0
Upper Leg Pathology	9	19	4	93	24

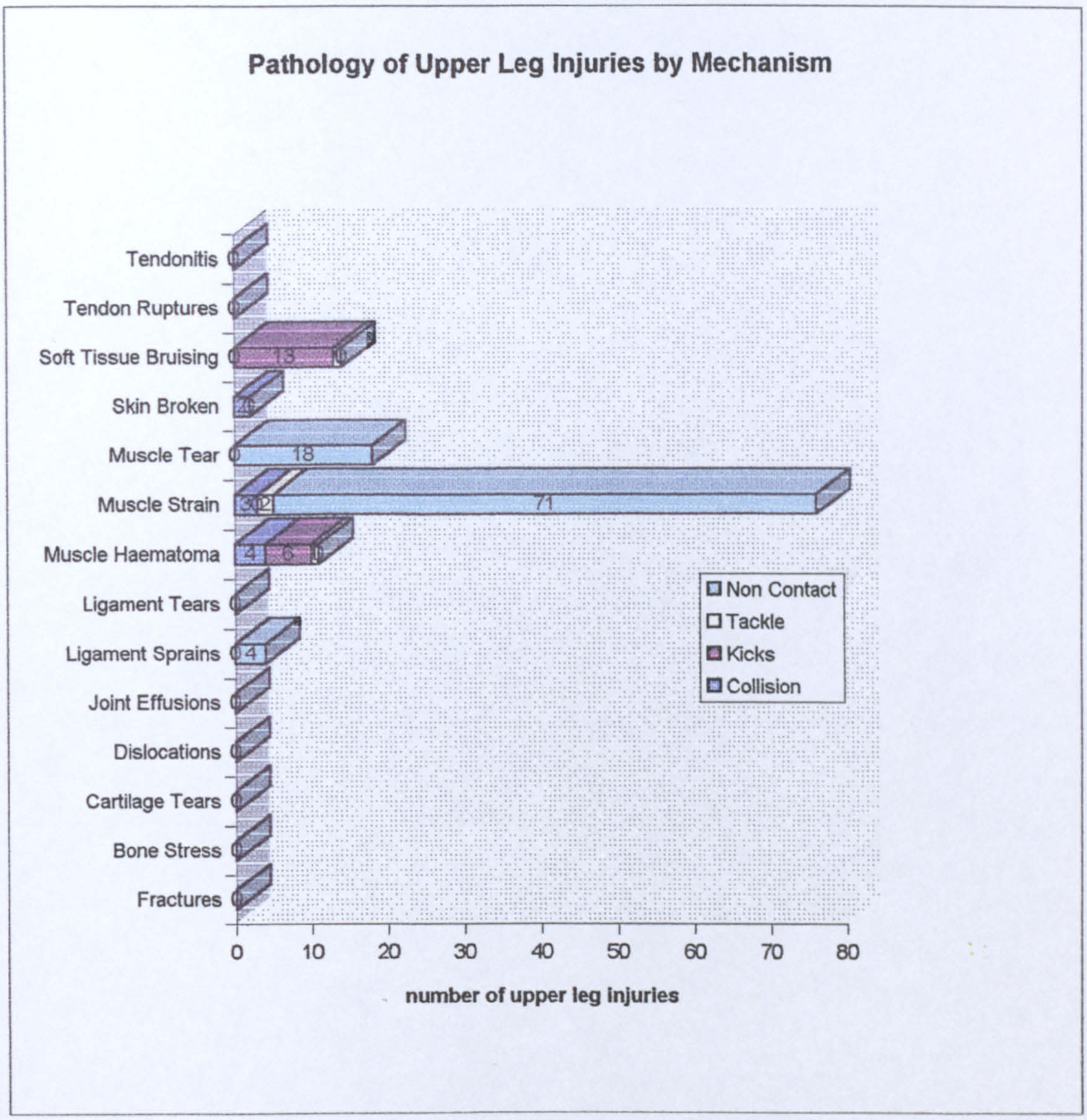


Fig 9.3

	Collision	Kick	Tackle	Non Contact	Recurrent Pathology
Fractures	1	0	4	0	0
Bone Stress	0	0	0	0	0
Cartilage Tears	0	0	0	0	0
Dislocations	0	0	0	0	0
Joint Effusions	0	0	0	0	0
Ligament Sprains	6	4	38	20	8
Ligament Tears	2	0	0	0	1
Muscle Haematoma	0	0	0	0	0
Muscle Strain	0	0	0	0	0
Muscle Tear	0	0	0	0	0
Skin Broken	0	2	0	1	0
Soft Tissue Bruising	1	15	6	1	0
Tendon Ruptures	0	0	1	0	0
Tendonitis	0	0	0	30	13
ANKLE PATHOLOGY	10	21	49	52	22

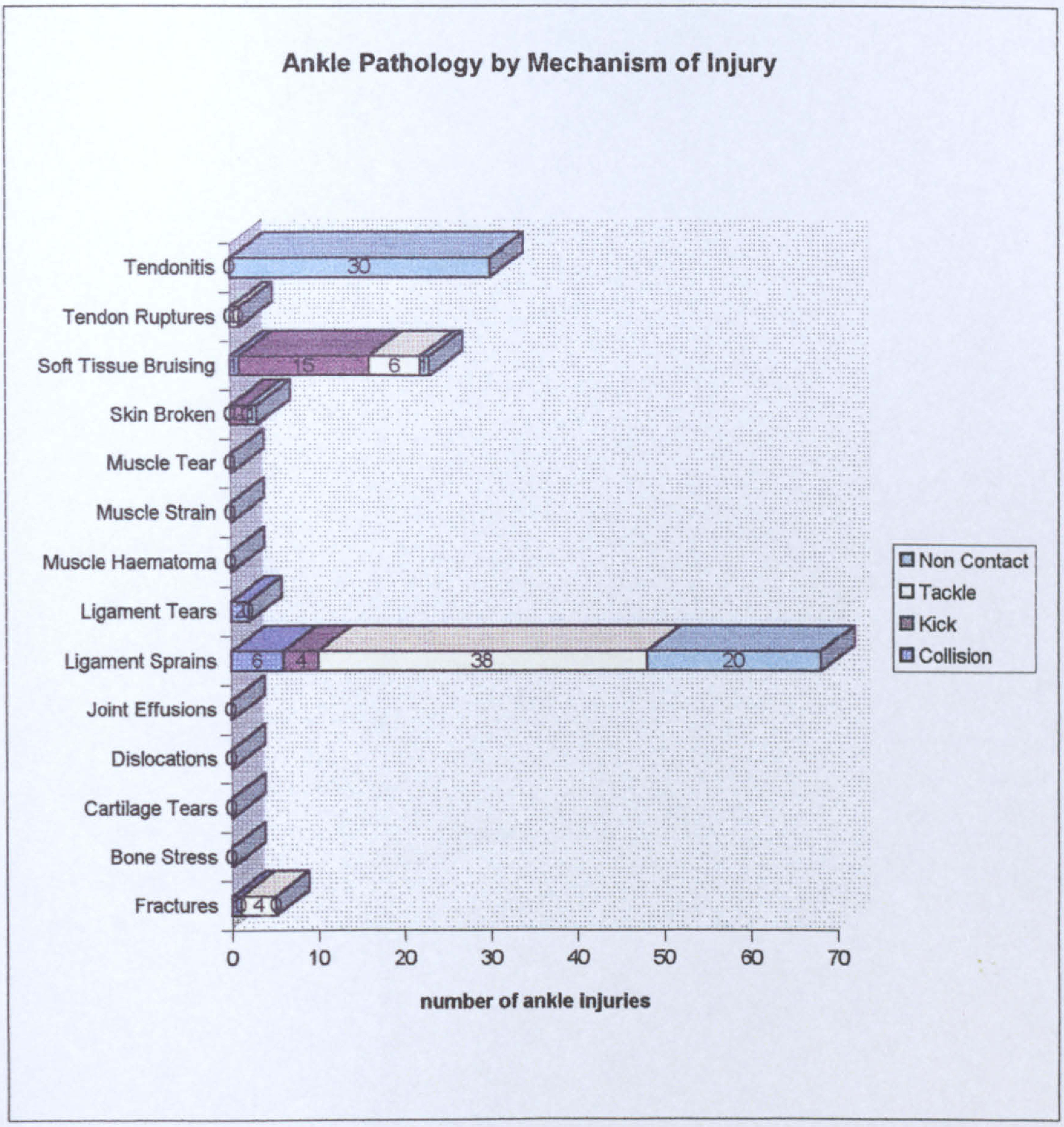


Fig 9.4

	Collision	Kick	Tackle	Non Contact	Recurrent Pathology
Fractures	0	1	0	1	0
Bone Stress	0	0	0	2	2
Cartilage Tears	0	0	2	4	4
Dislocations	0	0	0	0	0
Joint Effusions	1	0	0	4	1
Ligament Sprains	9	1	22	20	19
Ligament Tears	2	1	5	1	4
Muscle Haematoma	0	1	0	0	0
Muscle Strain	0	0	0	0	0
Muscle Tear	0	0	0	0	0
Skin Broken	0	1	0	0	0
Soft Tissue Bruising	3	8	2	2	0
Tendon Ruptures	0	0	0	2	2
Tendonitis	0	0	0	3	0
KNEE PATHOLOGY	15	13	31	39	32

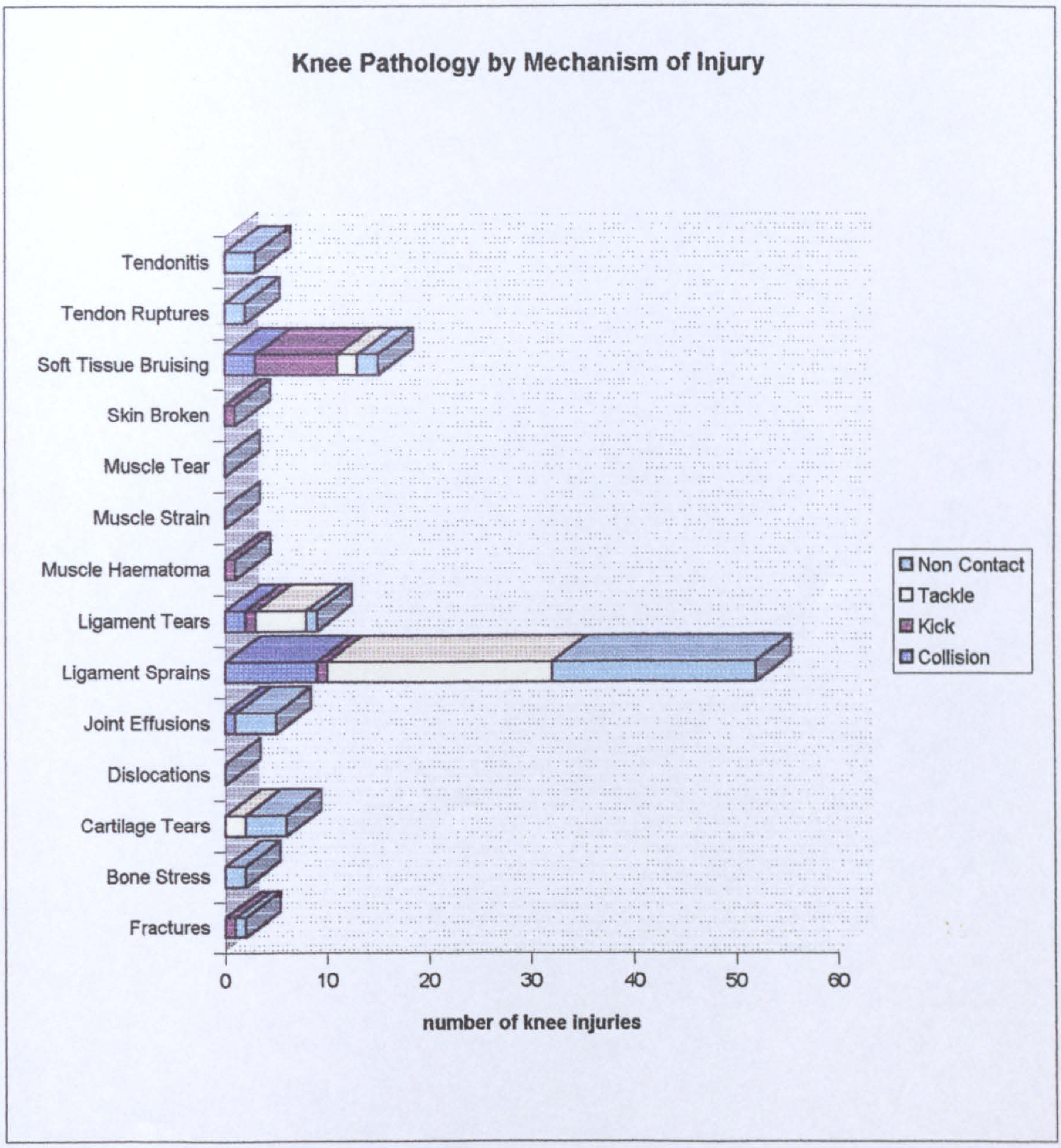


Fig 9.5

	Collision	Kicks	Tackle	Non Contact	Recurrent Pathology
Fractures	0	0	0	0	0
Bone Stress	0	0	0	1	1
Cartilage Tears	0	0	0	0	0
Dislocations	0	0	0	0	0
Joint Effusions	0	0	0	0	0
Ligament Sprains	0	0	1	10	3
Ligament Tears	0	0	0	2	1
Muscle Haematoma	0	0	0	0	0
Muscle Strain	2	0	2	20	5
Muscle Tear	0	0	2	12	0
Skin Broken	0	0	0	0	0
Soft Tissue Bruising	0	0	0	1	0
Tendon Ruptures	0	0	0	3	2
Tendonitis	0	0	0	9	6
GROIN PATHOLOGY	2	0	5	58	18

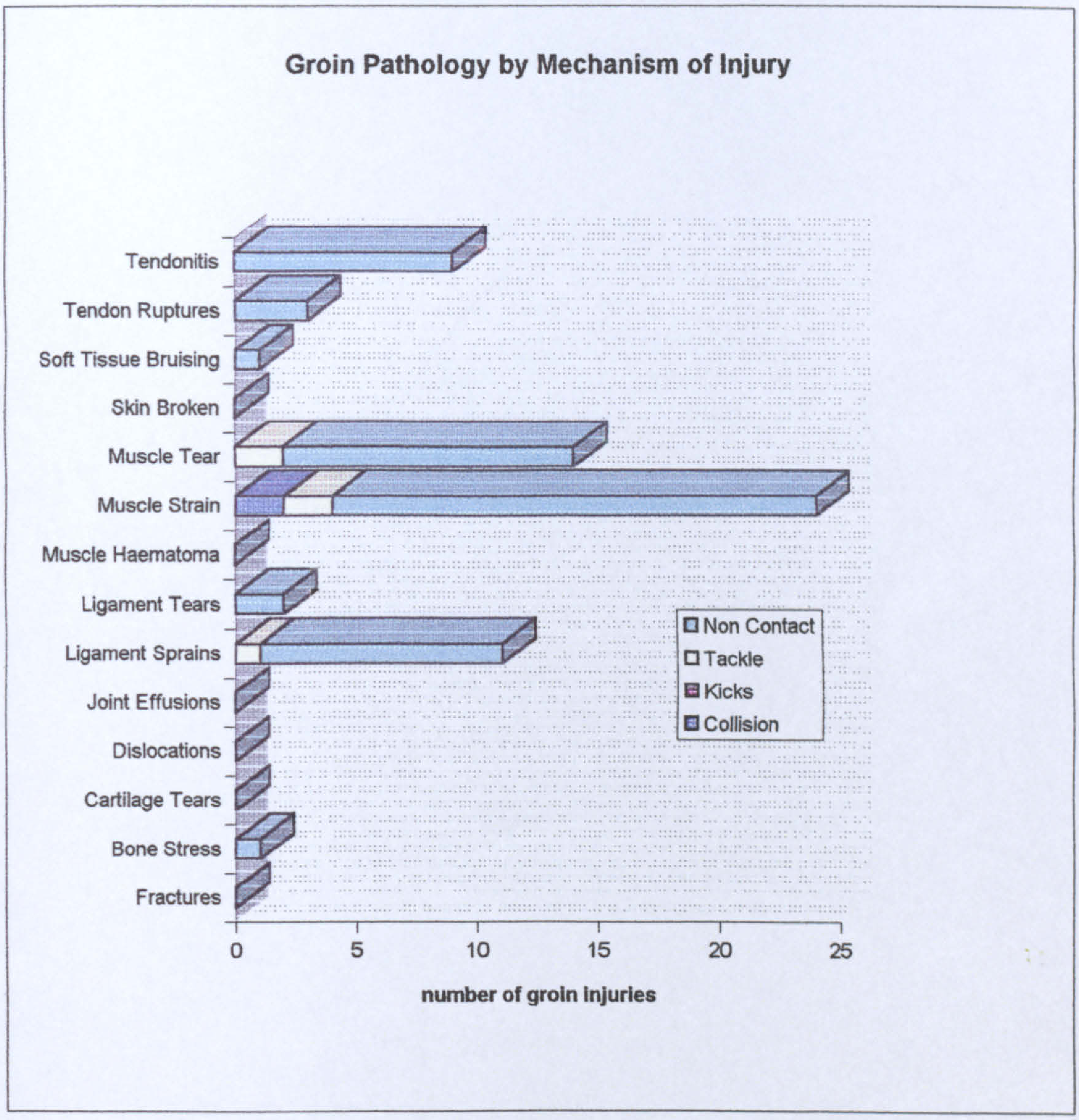
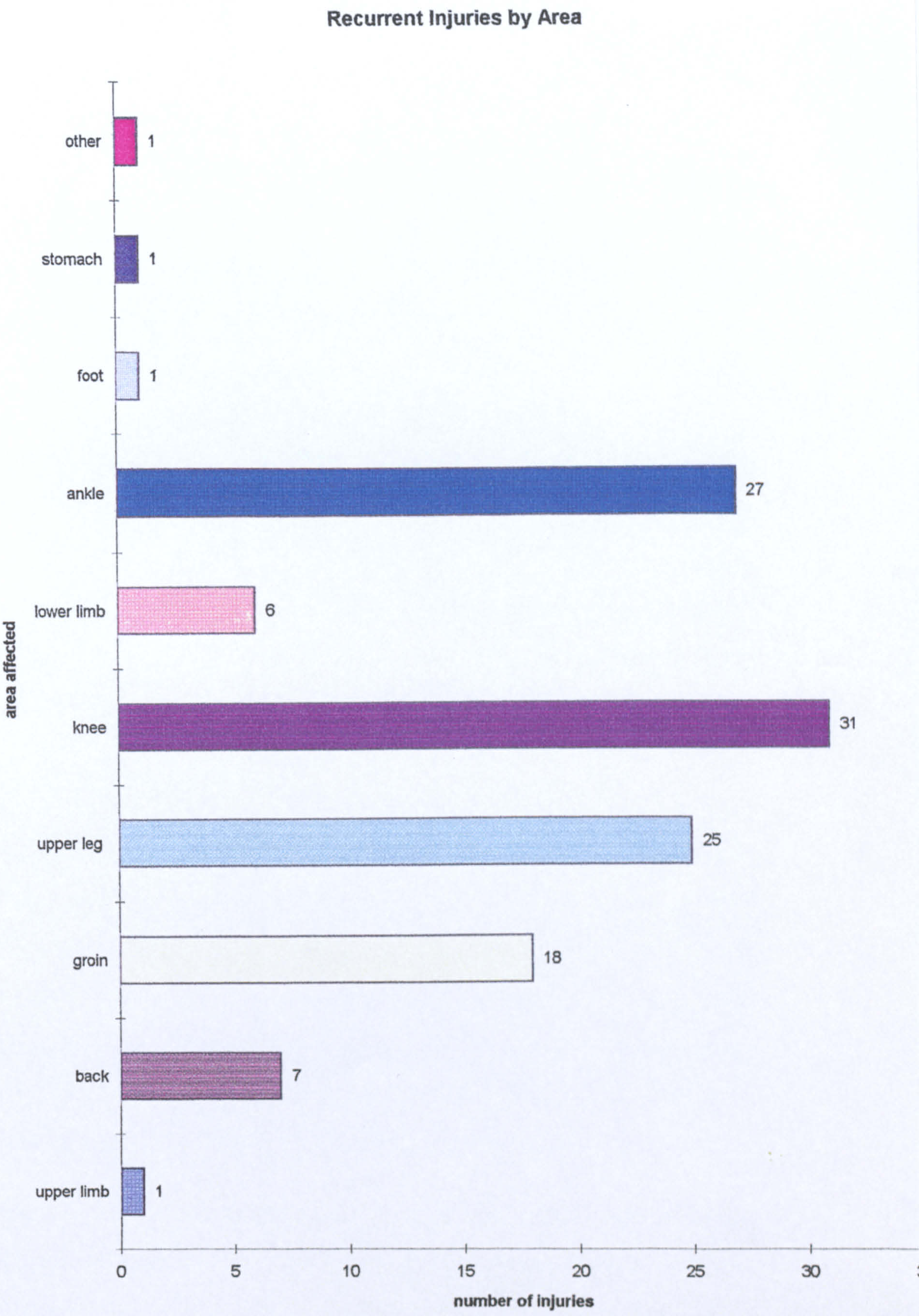


Fig 9.6.


Recurrent Injuries by Area
other
stomach
foot
ankle
lower limb
knee
upper leg
groin
back
upper limb
area affected
1
1
1
27
6
31
25
18
7
1
0
5
10
15
20
25
30
number of injuries

10. Injury Recurrence

The essence of Sports Medicine is to prevent injury and its recurrence. Injury recurrence accounted for 19% (121) of the 644 injuries reported during Season '93-'94. (34 not specified). Injury recurrence is especially important as this may give rise to significant morbidity after what was initially a relatively minor injury. Surprisingly injury recurrence has not been studied extensively and is often only briefly alluded to in the reporting of soccer injury epidemiology.

10.2. Mechanism of Recurrent Injury

As approximately one in five injuries were recurrent (Figure10.1), it was important to study the mechanism of these injuries in detail (Figure 10.2). Remarkably 74% (89) of the recurrent injuries were non contact injuries, unrelated to the physical contact associated with soccer. Fourteen percent (17) of the injuries resulted from tackles with approximately 2% occurring during collisions and 2% while kicking. Unfortunately the exact mechanism of injury for 4% of the recurrent injuries was not specified.

10.3. Pathology of Recurrent Injury

A spectrum of pathologies were responsible for the recurrent non contact injuries (Figure 10.3). These injuries predominantly relate to the overload and overuse of tissues either due to a physiological weakness from previous injury or due to the persistent overload associated with competition and training. Muscular injuries accounted for 34% (41) of all recurrent injuries, followed closely by ligamentous injuries 31% (37). Interestingly, 20% (24) of recurrent injuries related directly to tendon pathology with 8% classed non specifically as soft tissue injury.

As illustrated on the bargraph titled "Detailed Pathology of Recurrent Injuries" (Figure 10.4), a muscular strain 28% (34), was the commonest cause of injury recurrence. Ligament sprains were clearly prone to recurrence 25% (30) as with tendon inflammation 17% (24). These three pathologies are predominantly responsible for recurrent injuries and the appropriate treatment and rehabilitation following such injuries merits detailed analysis. A spectrum of other conditions were responsible for the remaining recurrent injuries; as might have been anticipated, the most significant injuries such as ligamentous tears (6%), muscular tears (5%), and tendon ruptures (3%) proved difficult to treat and were responsible for injury recurrence.

10.4. Recurrent Injuries by Position

As far as is known, injury recurrence has not been assessed in detail as it relates to player position. As illustrated (Figure 10.5), there appears to be no significant variation in the frequency of injury recurrence according to player position. Slightly fewer midfield players sustained recurrent injuries during the Season '93-'94, although the significance of this difference is not clear. Surprisingly goalkeepers in this study were less prone to recurrent injury.

10.5. Recurrent Injuries During the Season

Non contact injuries were primarily responsible for the majority of recurrent injuries throughout the season (80%). For this reason the non contact injuries as a subgroup, were assessed throughout the season and the pattern analysed. The majority of recurrent non contact injuries occurred during the first quarter of the season (31%) and the last quarter (29%). It is also apparent from the graph (Figure 10.6), that halfway through the season the injury frequency dips slightly and may relate to the festive break or the extreme weather conditions.

Interestingly, 121 recurrent injuries reported were shared amongst 86 players (Figure 10.8). Seventy-four percent of the players sustained only one recurrent injury during the season, however there was a small percentage of players who are frequently troubled with the recurrence of the same injury. Seventeen percent (15) of players sustained two injury recurrences and 5% and 3% sustained three and four injury recurrences, respectively. Clearly the 8 players in the last two groups presented a significant challenge.

10.6. Recurrent Injuries by Area

The lower limbs are responsible for the majority of soccer injuries, representing 64% to 93% of injuries (Aglietti, 1994), and the most frequently injured areas are the ankle followed by the knee. This situation is reversed when the recurrent injuries are studied in detail (Figure 10.7). The knee injury recurrence predominated representing 26% (31) of the recurrent injuries. This is thought to relate to ligamentous instability or meniscal pathology. It is important to recognise that the anterior cruciate ligament deficiency may contribute to this problem of recurrence. Aglietti (1994) found a 47% incidence of ACL lesions associated with knee sprains and a similar figure was reported by Engström (1990) who found ACL lesions in 44% of knee sprains.

The ankle was the next most frequently affected area representing 23% (17) of the recurrent injuries.

Upper leg injuries accounted for 21% and groin injuries 15% of recurrent injuries. As these injury groups often overlap, together they would represent 36% of all recurrent injuries, which indeed represents a demanding clinical challenge. Seven recurrent back injuries were also reported.

10.6.1. Recurrent Injuries by Area in Detail

Recurrent injuries were then assessed anatomically according to the most frequently affected areas. Put in context as illustrated (Figure 10.9) with the total number of injuries affecting each area represented, it was clear that although the ankle was the most frequently injured area (184), injury recurrence accounted for only 15% (27). By contrast, although the knee was less frequently injured (121) recurrent injuries accounted for 26% of these (32). Likewise in the case of the groin, although less frequently injured (70), 26% of the reported injuries were recurrent (18). A similar situation is apparent for upper leg injuries, with recurrent injuries representing 19% (25).

10.7. Mechanism of Recurrent Injuries by Area

Recurrent injuries were reviewed according to the mechanism of injury. Knee injuries are caused by a variety of mechanisms. The appropriate graph (Figure 10.10), clearly illustrates how injury recurrence affecting the knee can be caused by collisions, kicks and tackles, although most recur without contact. This is in marked contrast to recurrent groin injuries which are almost exclusively caused by non contact mechanisms as illustrated (Figure 10.10). Not surprisingly upper leg injuries tend to follow a similar pattern to groin injury.

10.8. Discussion

Soccer injury prevention demands an adequate understanding of the risks of injury recurrence and an appreciation of the importance of rehabilitation. It is clear from these results that injury recurrence remains at an unacceptably high level in Scottish football. Approximately 1 in 5 injuries were recurrent. Seventy-four percent (89) of recurrent injuries in this study arose without contact and muscular strains (28%), ligament sprains (25%) and tendon pathology (17%) were responsible for most.

Ekstrand and Gillquist (1983) studied the efficacy of an injury prevention programme. Interestingly, with the provision of player information and the supervision of training and rehabilitation, <u>no</u> recurrent injuries within the test group were reported, compared with 31 of the 93 injuries within the control group ($\chi^2 = 8.83$ $p < 0.001$). They identify inadequate rehabilitation as the main factor in 13 of the 31 cases and conclude that many recurrent injuries reflected the lack of knowledge among players and coach concerning rehabilitation after injury

The implication from this work is that with early diagnosis and appropriate supervised rehabilitation the recurrent injury rate (20%) identified in this study could be reduced dramatically. The importance of a preseason medical should be emphasized to identify potentially vulnerable individuals. This should include a detailed knee and ankle assessment to ensure full range of joint movement, adequate stability, and muscular strength.

Muscular injury accounted for 34% of recurrent injuries in this study and this is unacceptably high. From the coach's perspective training should improve the general physical condition of players and should not result in excessive fatigue leaving muscle exposed to injury. Training should also incorporate techniques to minimise the risk of injury. Strength training, for example, will enable the musculo-tendinous unit to absorb more elastic energy and therefore provide some protection from injury. All this requires to be planned in advance.

It is important that stretching is passive and pain free to minimise the risk of muscular strain and that rehabilitation is continued until the player is pain free, has normal strength and a full range of joint movement. If a player returns to play at this point then the risk of recurrent muscular injury is at least minimised.

In conclusion, injury recurrence in soccer remains a significant problem. The diagnosis, treatment and rehabilitation after muscle strains, ligament sprains and tendinitis must be improved, especially when they involve the knee, ankle or groin. An awareness of the incidence of injury recurrence and its consequences present a significant challenge to the Club Doctor, Physiotherapist and Coach.

Fig 10.1

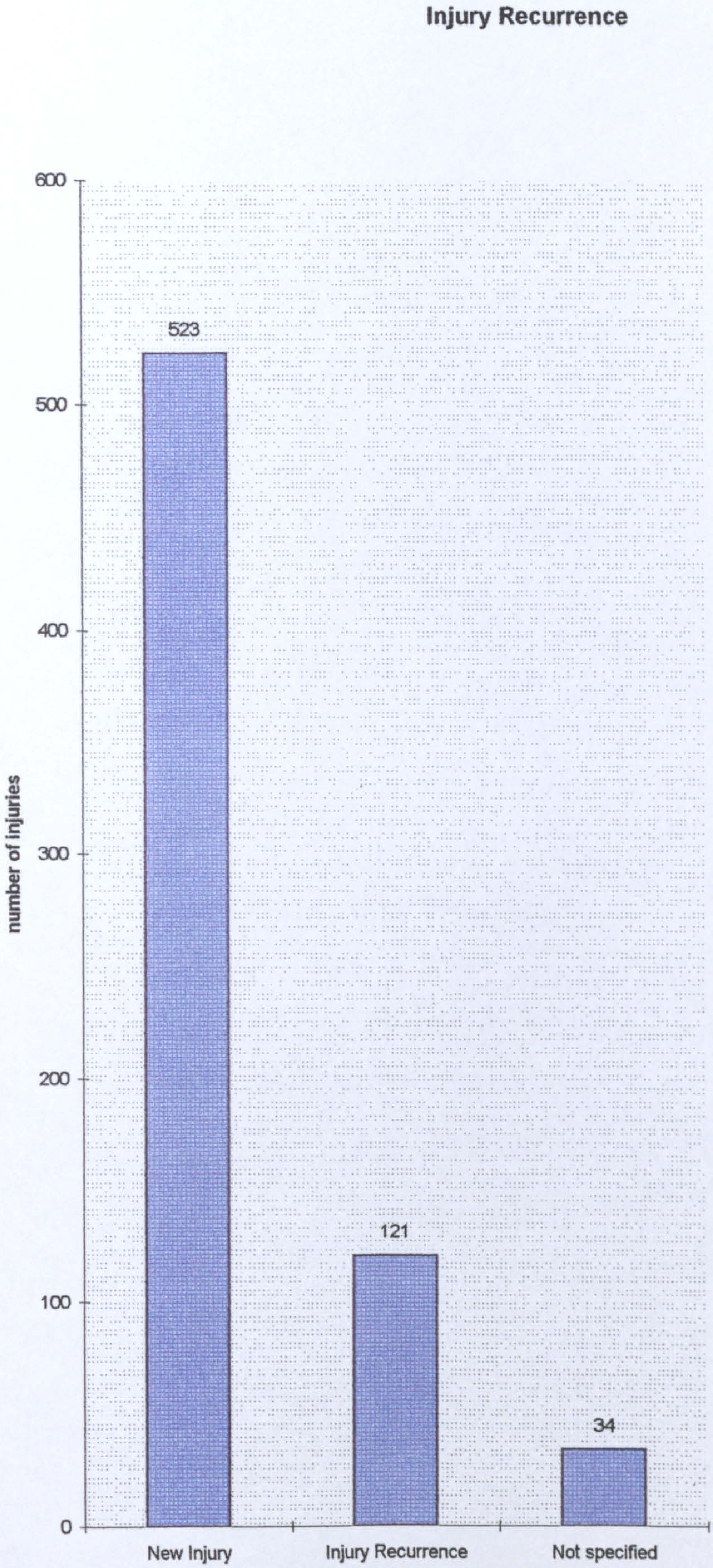

Injury Recurrence
number of injuries
600
500
400
300
200
100
0
523
121
34
New Injury
Injury Recurrence
Not specified

Fig.10.2

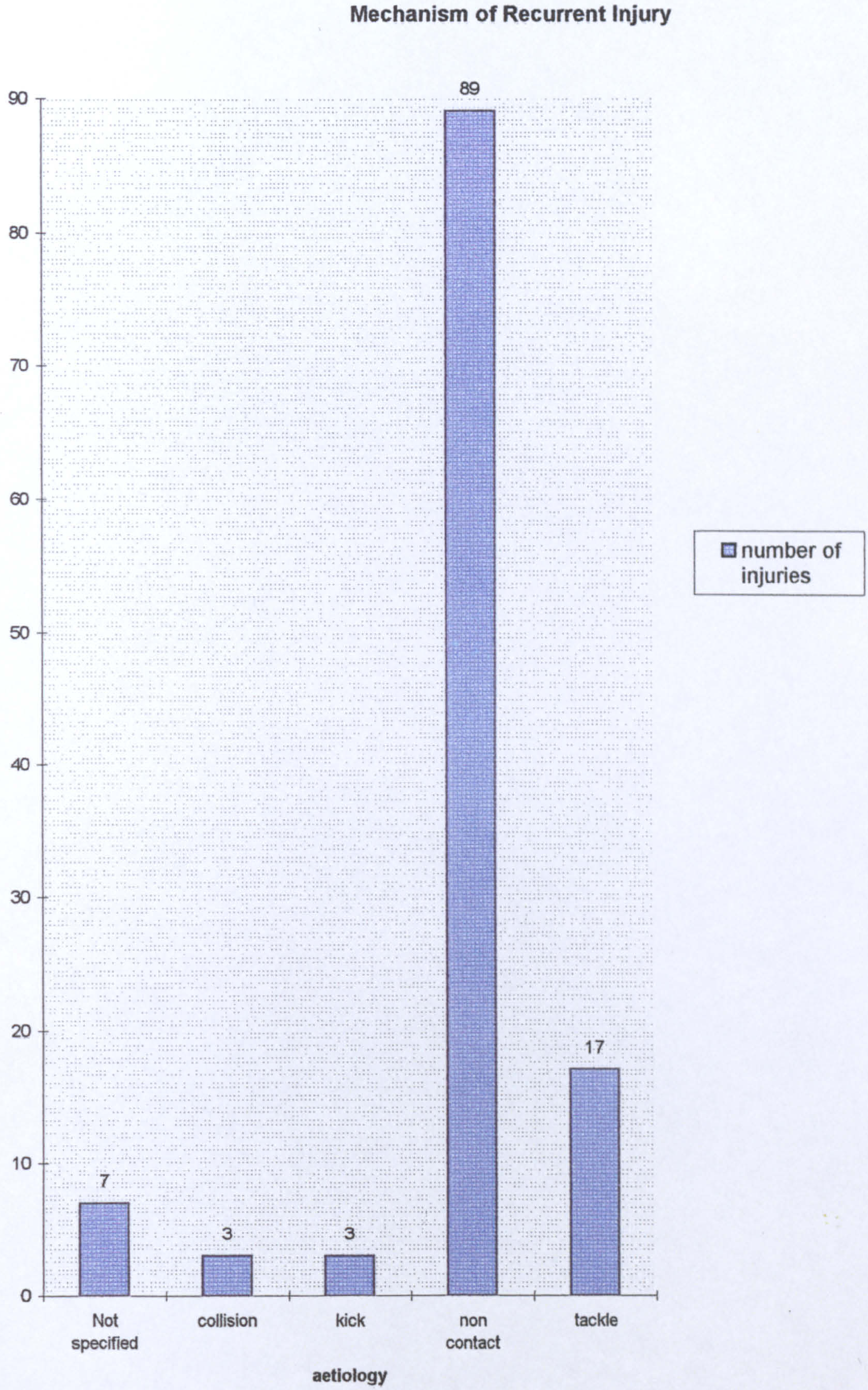
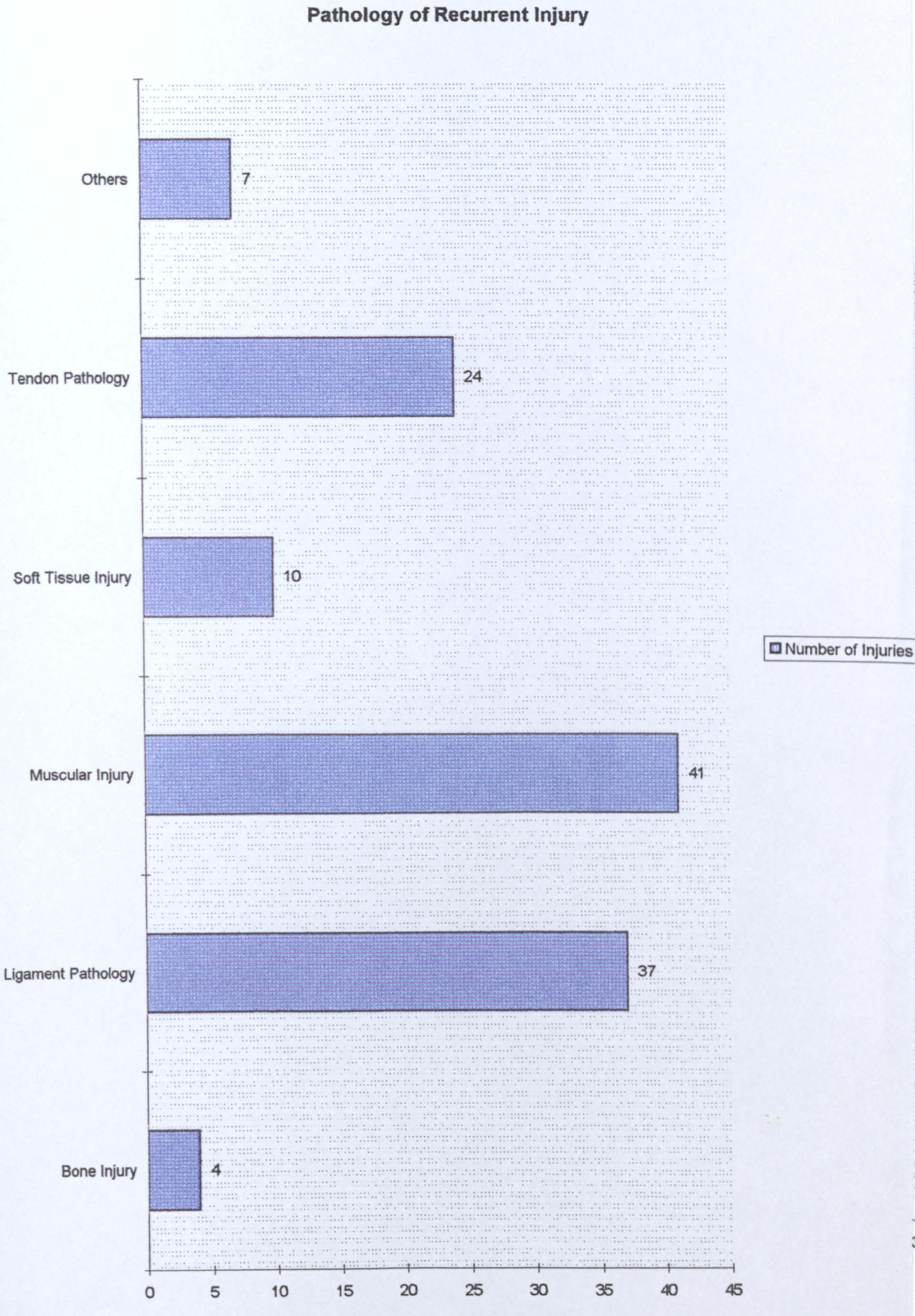

Mechanism of Recurrent Injury
90
80
70
60
50
40
30
20
10
0
89
17
7
3
3
number of injuries
Not specified
collision
kick
non contact
tackle
aetiology

Fig. 10.3



Sports Injury Study

Fig 10.4

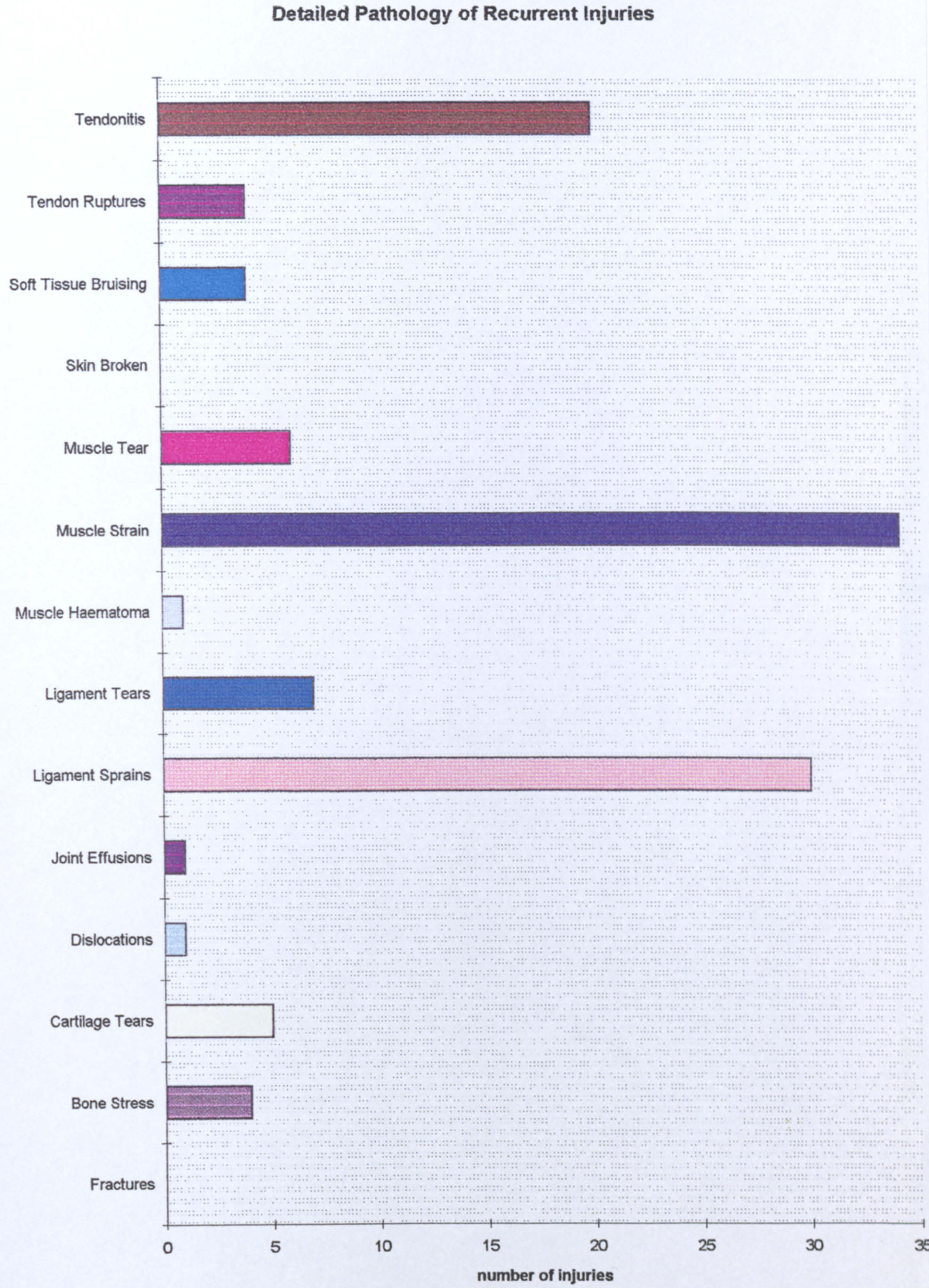
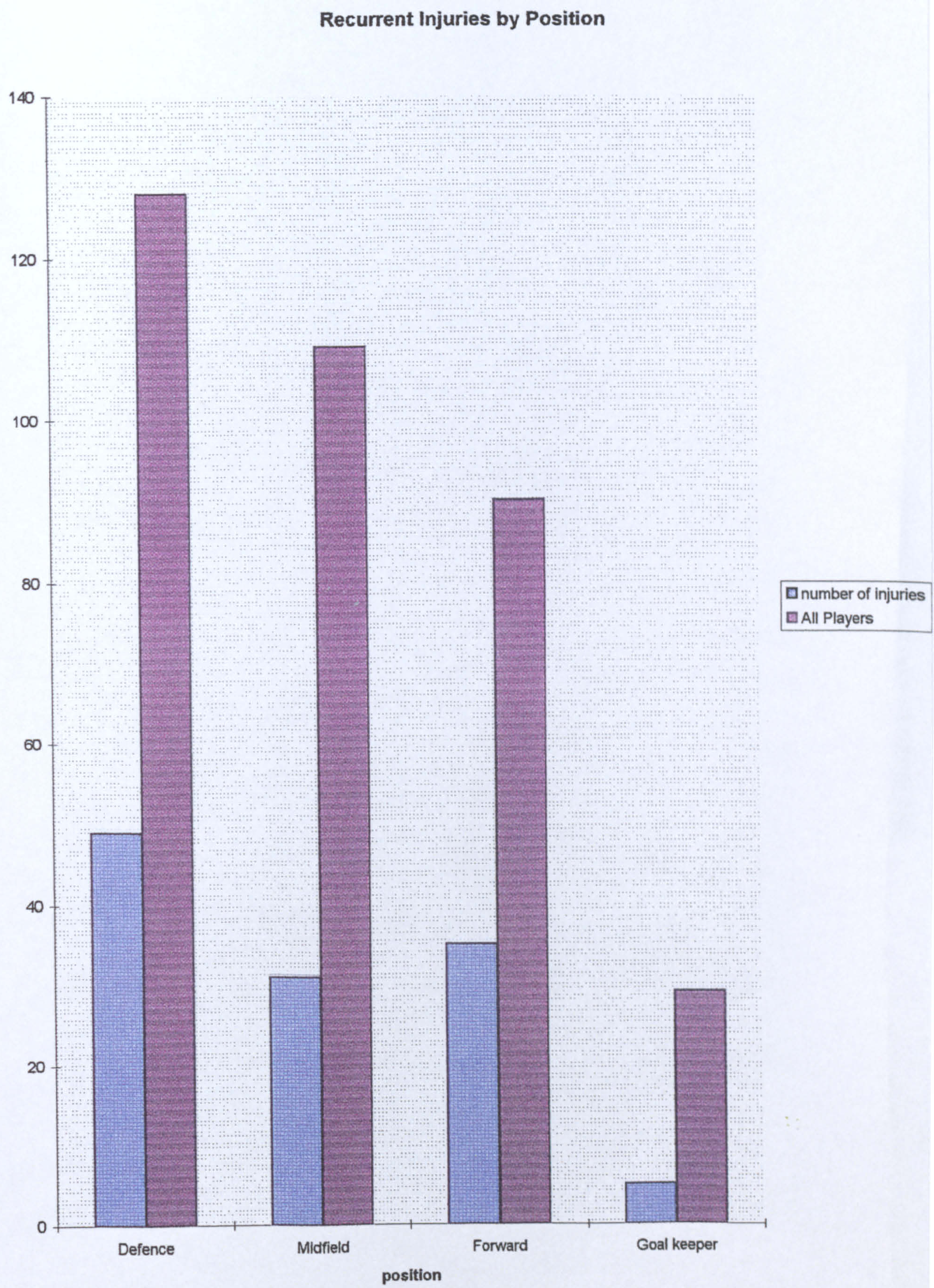
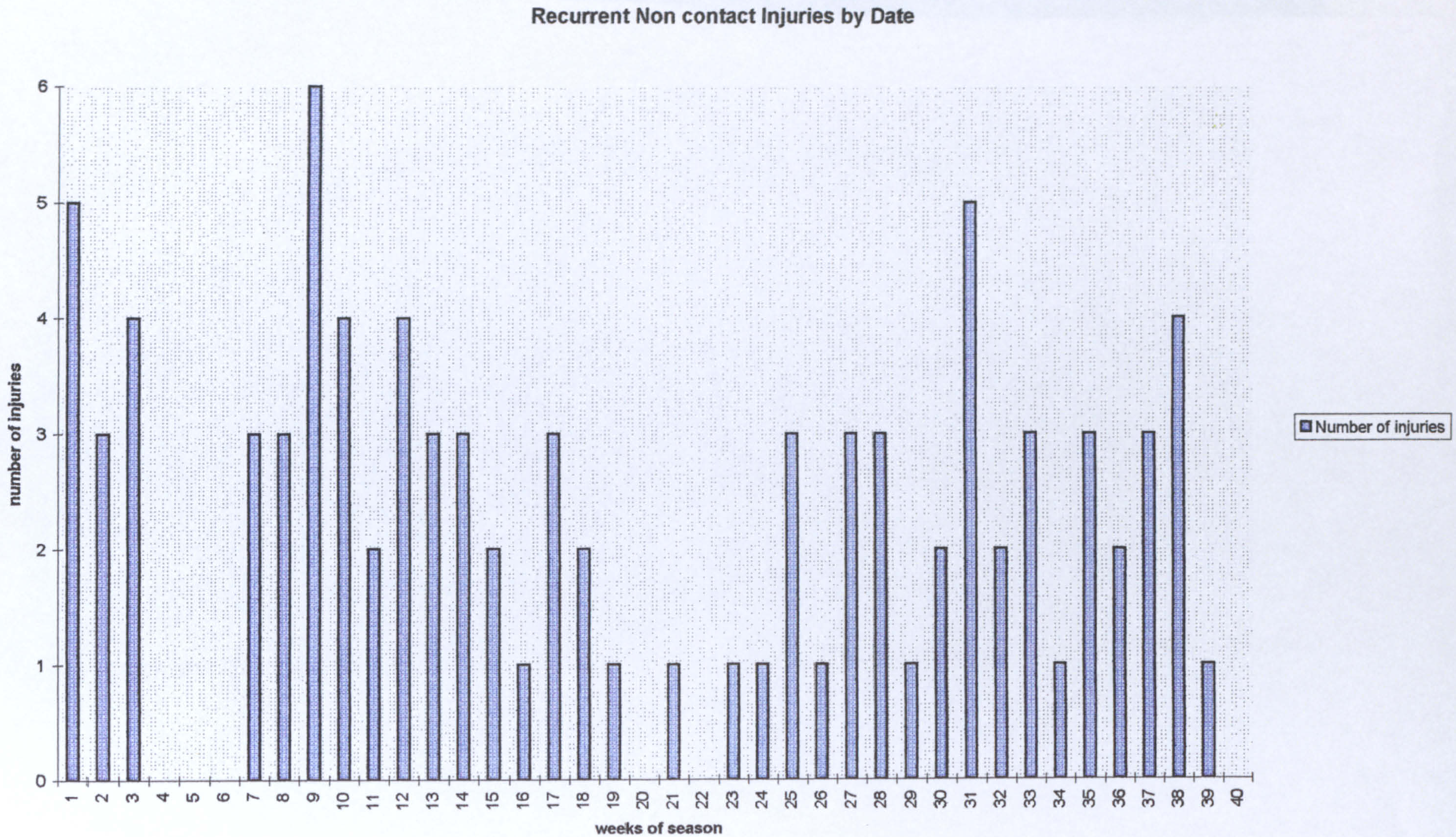

Detailed Pathology of Recurrent Injuries
Tendonitis
Tendon Ruptures
Soft Tissue Bruising
Skin Broken
Muscle Tear
Muscle Strain
Muscle Haematoma
Ligament Tears
Ligament Sprains
Joint Effusions
Dislocations
Cartilage Tears
Bone Stress
Fractures
0
5
10
15
20
25
30
35
number of injuries

Fig 10.5.



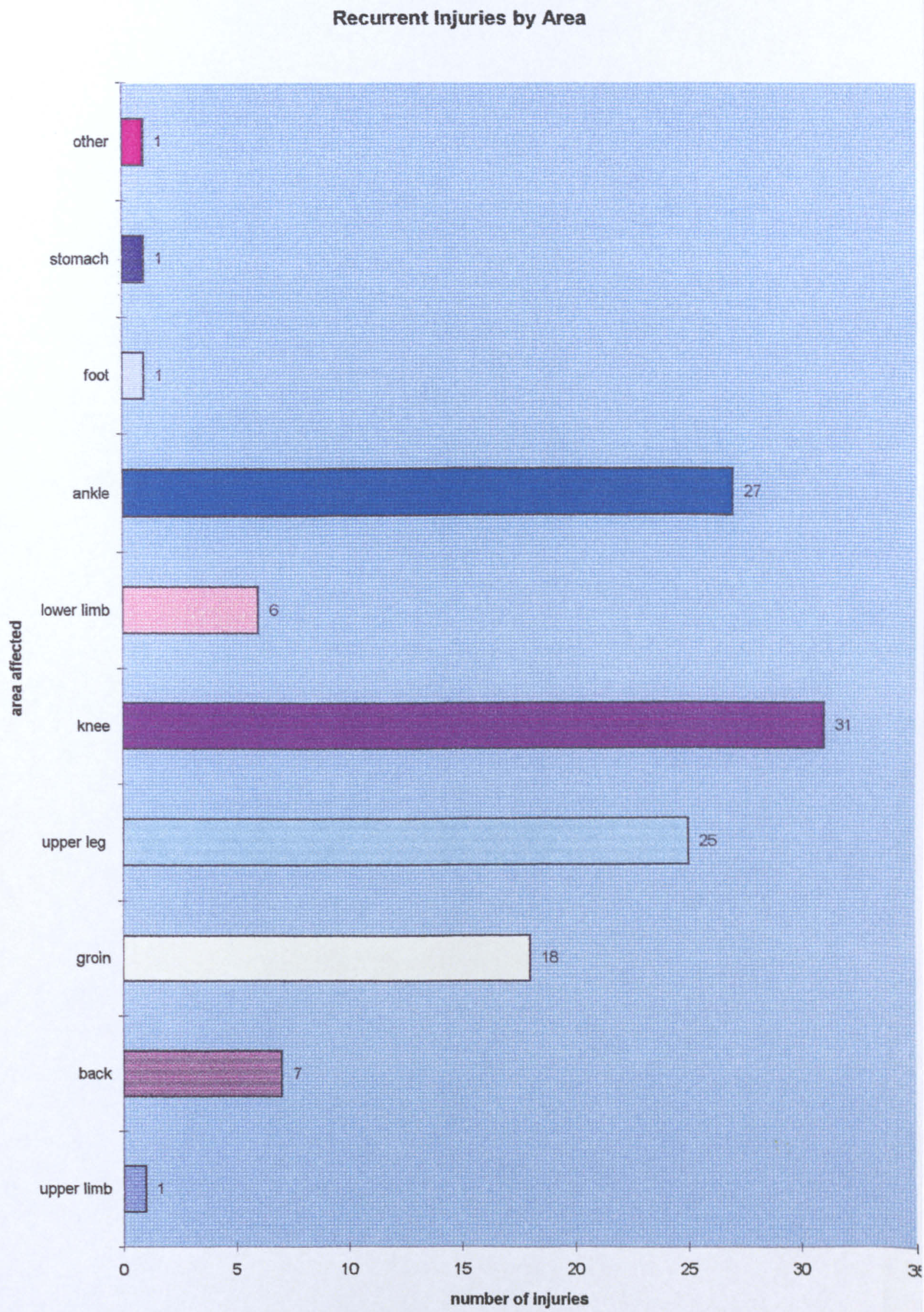
Recurrent Injuries by Position
140
120
100
80
60
40
20
0
Defence
Midfield
Forward
Goal keeper
position
number of injuries
All Players

Fig 10.6



Sports Injury Study

Fig. 10.7.



Recurrent Injuries by Area
area affected
other
stomach
foot
ankle
lower limb
knee
upper leg
groin
back
upper limb
1
1
1
27
6
31
25
18
7
1
0
5
10
15
20
25
30
35
number of injuries

Fig. 10.8

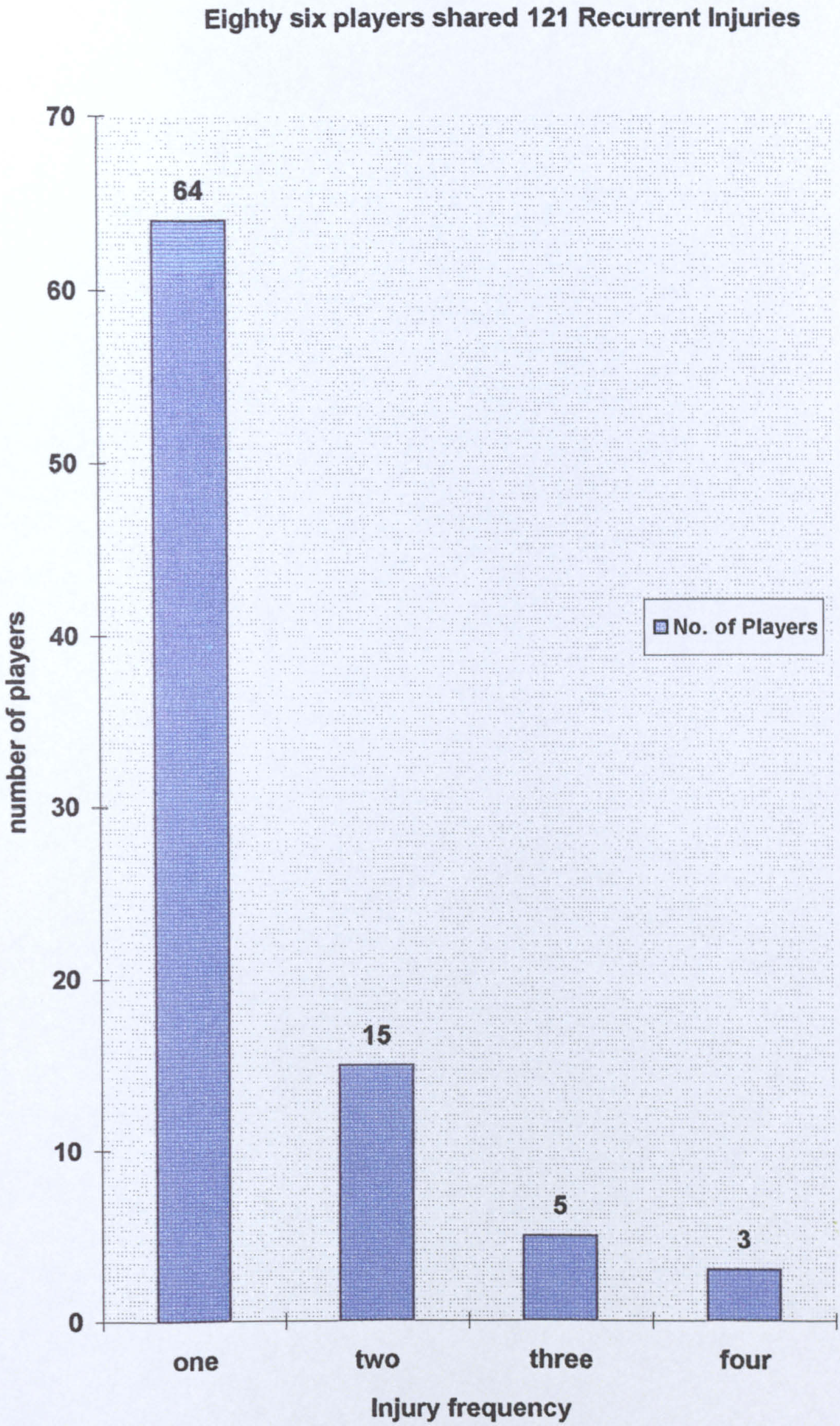
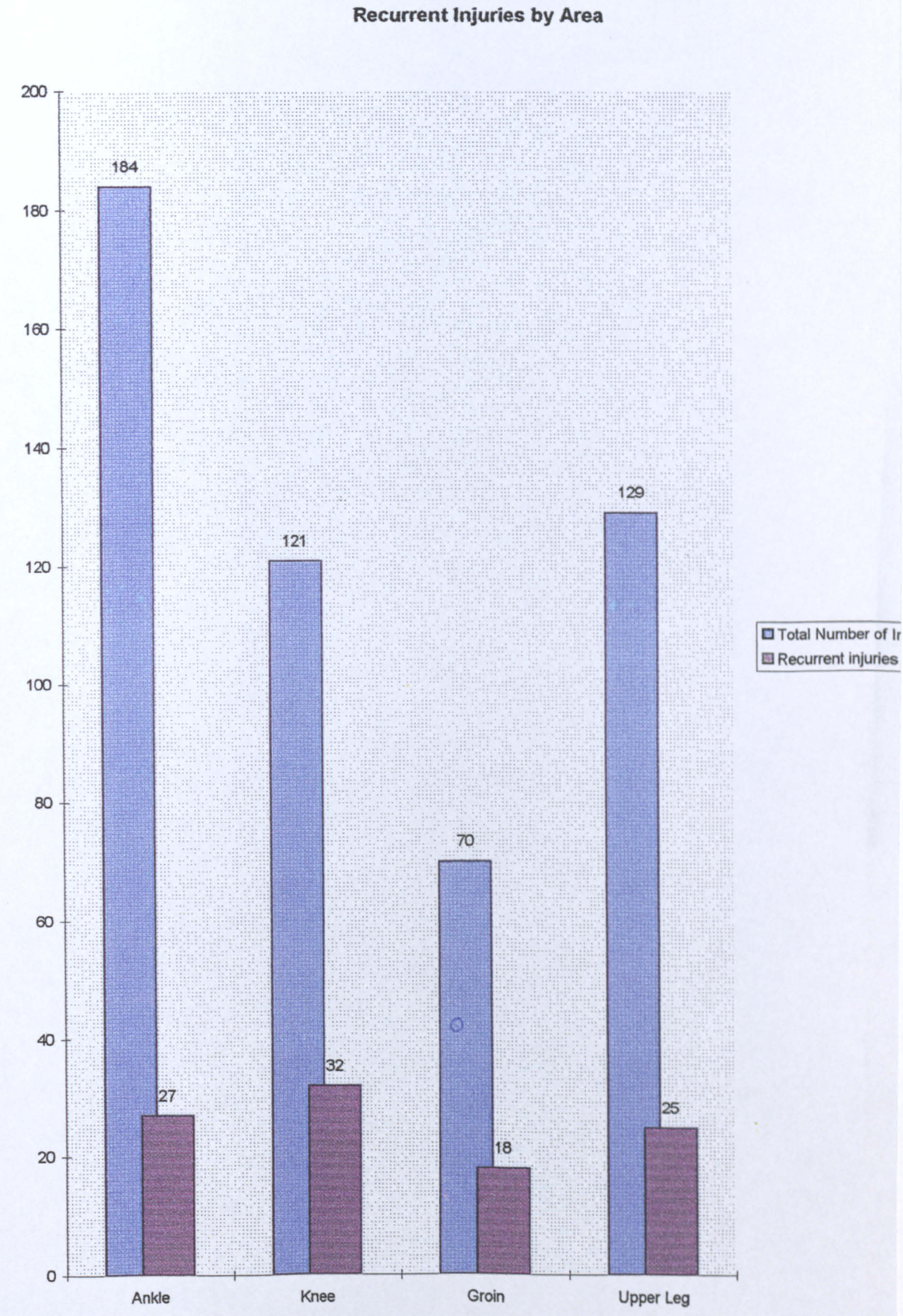

Eighty six players shared 121 Recurrent Injuries
70
60
50
40
30
20
10
0
number of players
64
15
5
3
No. of Players
one
two
three
four
Injury frequency

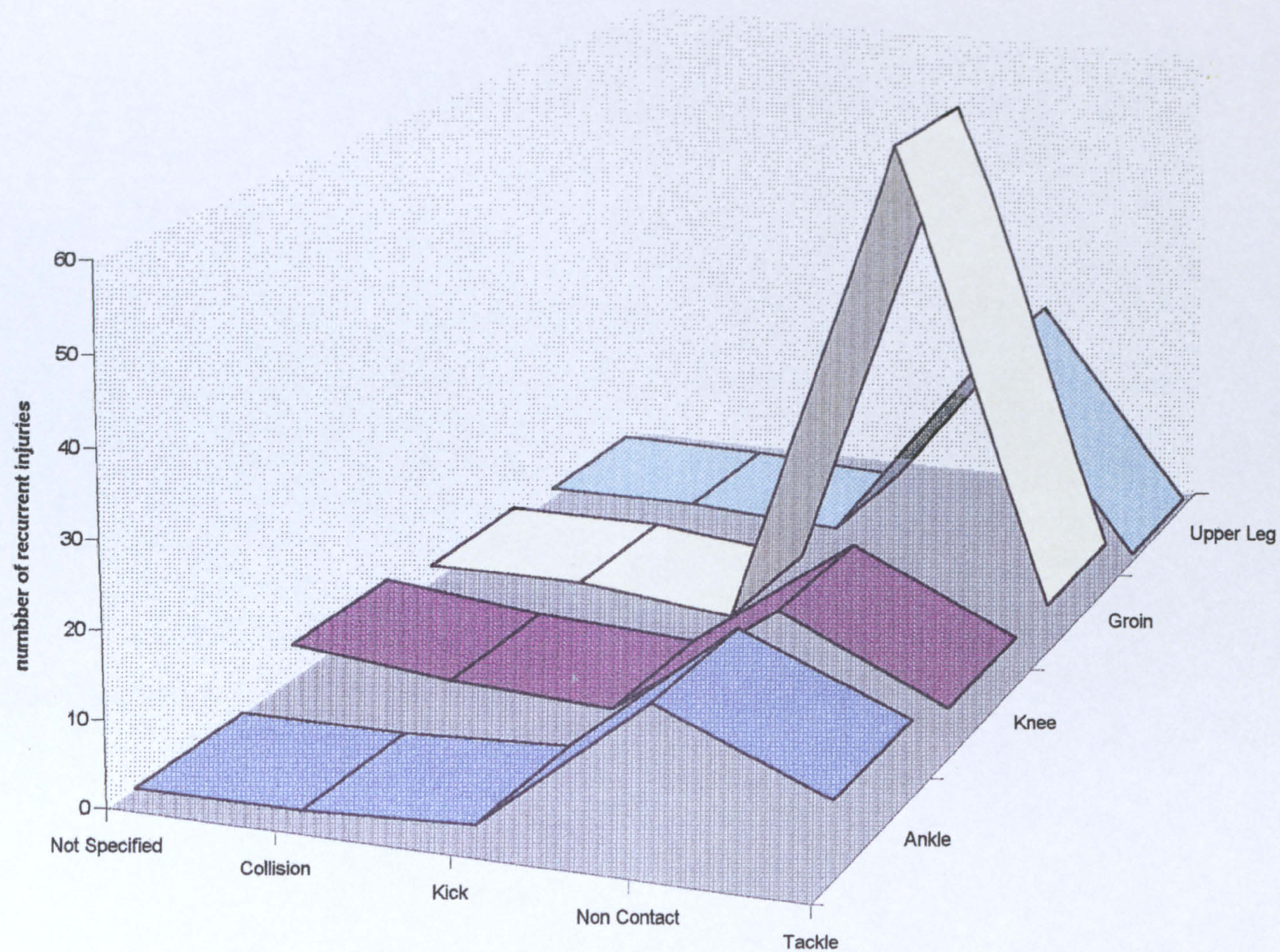
Fig 10.9.5



Sports Injury Study

Fig 10.10

Mechanism of Recurrent Injuries by Area



11. Results - Surgery

11.1. Introduction

Of all injuries treated in hospitals 3.5 to 10% are due to soccer. Inevitably, associated with this degree of morbidity a percentage of players will require surgical intervention.

11.1. Players Requiring Surgery

A total of 342 players representing 19 clubs completed this study and the surgical requirements were analysed in detail. It was felt that any further analysis from incomplete or partially completed injury reports could give rise to spurious conclusions and this data has been excluded. The degree to which this form of self selection may bias the final conclusions is open to speculation although it is not thought to be important.

During the season 8.8% (30) players required surgery and shared a total of 33 operations (Figure 11.1). Almost 1 in 10 players therefore required surgery during the season with all that entails.

11.3. Operations

Not surprisingly, knee surgery was the commonest procedure with 13 operations being performed on 11 players. Two players initially had arthroscopic examinations and subsequently required further reconstructive procedures. The whole question of knee surgery will be put in context and discussed later in this chapter. The next most frequent operation performed was that of groin or hernia surgery which involved a total of six players. A similar number of players requiring this surgery were also identified from the clubs which did not fully complete the study and are therefore not formally reported here. This gives an insight into the frequency of what used to be a very rare procedure among young athletic individuals, but this has increasingly been turned to as a last resort often with good effect.

A variety of other operations were required involving the face (often the maxilla), hand and foot. Achilles surgery was required for four players, all of whom had recurrent achilles tendinitis and one case was reported as a complete rupture. Of interest was the fact that no ankle surgery was required.

11.4. Injury Analysis

Injuries requiring surgical intervention were analysed in detail. The results have been illustrated (Figure 11.2), and can be summarised as follows. Most authors have reported the majority of traumatic injuries occur during match competition (77%), as opposed to training, however 23 (68%) of the injuries requiring surgery during the season '93 - '94, occurred during or as a result of training. The implication is that this may well relate to overload or overuse. This impression was indeed reinforced when the mechanism of injury was analysed. It was apparent that the majority of injuries which required surgery 25 (75%), were non contact and only 8 (25%) were the result of direct contact.

Non contact injuries can be due to intrinsic or extrinsic factors which, if not addressed appropriately, give rise to injury recurrence (Figure 11.3). This was certainly a contributing factor as 36% of players, who required surgery had injuries which were classified as recurrent.

All players requiring surgery were identified and their average age assessed and compared with all the players participating in this study. The average age of the 30 players requiring surgery was 25.96 years which was not statistically different from the average age of all 342 players which was 26 years (Figure 11.4).

Player position was assessed in detail (Figure 11.5), as previous authors had differed in their findings, although surgery had not been looked at specifically. It was found that 56%(17) of players requiring surgery were defenders, 27%(8) were midfield and 17%(5) were forwards. It would certainly appear that even though defenders were the largest single group within the study (128 players, 37%), they were still excessively represented in the group requiring surgery. Due to the limited number of players requiring surgery it is only possible to identify an association although its significance is yet to be fully evaluated.

11.5. Knee Surgery

Knee surgery involving 14 players, was the commonest operation performed during the season. Of particular concern was the fact that 6 (44.8%) of these players have previously required knee surgery. As detailed in Chapter 4, 78 players of the 462 players retrospectively assessed had had previous knee surgery. Of the 342 who were included in the final study group 56 (16.4%) had previously required surgery. Obviously as illustrated on the chart entitled " Knee Surgery" (Figure 11.6), players who had previously required surgery were excessively represented in the group requiring surgery during the season '93 - '94. However since the proportions involved were so small, Fisher's exact test was used, $p=0.094$. (i.e. there is no strong association between previous knee surgery and "knee surgery" during this study.

11.6. Discussion

The epidemiology of injuries in soccer has tended to focus on injury risk. Injuries were graded according to severity as minor, moderate or severe, or by using a time loss classification to assess the severity of injury. This chapter has therefore taken a fresh perspective in looking at the surgical requirements of professional footballers in the United Kingdom.

Knee Surgery

Knee surgery was predictably well represented accounting for 44% (14) of all players requiring surgery. Although some clubs were reluctant to specify, or unable to specify in detail exactly what surgery was involved, it would appear that 2 players had an ACL disruption both arising from non contact injuries and one had a partial PCL disruption. Others were assumed to have meniscal pathology. To my knowledge no meniscal repair was performed.

Surgical reconstruction of the ACL was certainly justified (Aglietti *et al*, 1994, Sandberg 1987). Almost half of those requiring knee surgery had previously required knee surgery and a third of all players requiring surgery had injuries which were classed as recurrent. It is therfore possible to postulate that several players may well have carried injuries which were inappropriately rehabilitated or were not fully diagnosed, for example a chronic ACL rupture. Intrestingly, in this study 52 knee ligament sprains were reported (32 contact and 20 non contact) and only two ACL ruptures, in contrast, Aglietti (1994) diagnosed an anterior cruciate ligament lesion in 47% of knee sprains. Other risk factors which may have contributed to injury recurrence, include equipment, playing surfaces and rule violations, however no detailed comment can be made.

Ankle Surgery

Interestingly, no ankle surgery was performed. It is generally accepted that treatment of choice for grade 1 and grade 2 ankle sprains is conservative treatment. The return to soccer, however, after a grade 3 tear remains controversial. A critical review of all prospective randomised trials available, confirmed that functional treatment should be the treatment of choice of the acute tears of the lateral ligament. Evans *et al* (1984), described a radiological technique, to assess ankle stability and followed this with a prospective study to assess the value of operative repair. He concluded that there was no evidence that an operative repair offered any significant benefit and this is the currently held opinion. It can therefore be concluded that the ankle ligament injuries are being managed appropriately.

Achilles tendon repair was only required for one player but the management of an acute rupture remains controversial. Acute repair of achilles tendon allows early resumption of sporting activities with a relatively small risk of re-rupture (Jacobs *et al*, 1978). It was Nistor (1981) who reviewed 2,647 cases of achilles tendon rupture and assessed the incidence of surgical complications. He found that deep infection occurred in 1%, fistulae in 3%, skin or tendon necrosis in 2% and that there was a re-rupture rate of 2%. On the basis of this it is recommended that surgery should be performed only with optimal skin conditions. Turco and Spinella (1987) emphasised the importance of early surgical repair so that the appropriate physiological tension could be reapplied immediately to the musculotendinous unit. This topic is once again the focus of debate and has been addressed by Clancy (1996) who advocates surgical repair of an acute rupture with an application of plaster in a neutral as opposed to an equinus position.

Groin/ Hernia Surgery

Six players in this study required groin-hernia procedures which were essentially procedures to reinforce their lower abdominal wall. It was also reported that a few players were experiencing groin pain but were able to play through the discomfort with the plan to undergo surgery during the closed season. Chronic groin pain (athletic pubalgia) is a common problem in soccer and continues to present a diagnostic challenge for the medical personnel.

It is thought that repetitive loading especially with the forceful biomechanics of kicking, can give rise to stress in the region of the hip flexors adductors and the lower abdominal musculature. Typically the player experiences a gradual onset of groin discomfort which increases in severity, is provoked by activity and may last for several hours or days after the event. The pain tends to be localised in the inguinal area it does however radiate posteriorly to the ischium and superiorly to the lower abdomen. There is occasionally point tenderness especially at the superficial inguinal ring however this may not be present and no hernia may be palpable. Performing a twisting sit up to stress the internal oblique muscle can reproduce the symptoms and the diagnosis is largely clinical, as other forms of diagnostic imaging are less than satisfactory. The recommendation for acute groin pain is rest and then gradual conditioning before returning to sport, however once chronic groin pain is established it is important to take a detailed history to assess the pain cycle. Palpation will exclude musculo-tendinous discomfort which is aggravated by resisted exercises. It is important to exclude other pathologies which may involve the lower lumbar spine and pelvic pathology, this may include: inguinal hernia, osteitis pubis and prostatitis. Routine spinal, pelvic and rectal examination should be performed before assessing the musculoskeletal system in detail. It can be concluded, that weakness of the lower abdominal wall is essentially a diagnosis of exclusion. Surgical treatment for this type of groin pain involves suturing the transversus abdominus aponeurosis to the lower lacunar ligament and by reinforcing the conjoint tendon near its insertion along the pectineal eminence, in a modified Bassini type herniorrhaphy. The results of this approach were reported by Taylor *et al* (1991), and it was successful in relieving pain which was not improved by prolonged conservative treatment.

Although surgery in appropriate cases is reported to be highly successful, it still gives rise to concern that this operation should be required so frequently for young men participating in competitive soccer. There may be significant scope for preventative measures to improve the strength of lower back, abdominal muscles as well as the adductor group. There is also a temptation to proceed rapidly to surgery before adequate conservative measures have been exhausted. Other groin pathology amenable to surgery includes adductor pathology which may result from overuse such as increased training or kicking. Eccentric contraction in particular can give rise to microtears and if this does not respond adequately to conservative treatment then surgical exploration may be justified and in rare cases tenotomy performed.

Player Position and Age

Age was not found to have a association with the risk of requiring surgery during the playing season, however there did appear to be an association with player position. Of the players requiring surgery, 56% (17) were defenders, and although defenders were the largest group in the overall study they still only represented 37% (128) of the entire study group. Although only 30 players required surgery, this association appears to be significant, however statistically there was no strong evidence that the proportion of players requiring surgery differ for the different positions (Chi-squared=4.446, df2, p=0.108). This is in contrast with the retrospective results(chapter 4) which found that defenders and goal keepers as a group had previously required more knee surgery (Chi-squared=14.735, df3, p=0.002). Positional variation would be in keeping with the findings of Sullivan *et al*, (1980), although he was assessing crude injury rates as opposed to surgical outcomes. In contrast, Ekstrand and Gillquist (1983), McMasters and Walters (1978), and Engstrom in 1990 identified no positional effect on the overall injury rate within a team. Aspects of surgery as it relates to the level of competition and injury recurrence have already been discussed in the appropriate chapters (Chapters 7 and 10 respectively).

Conclusion

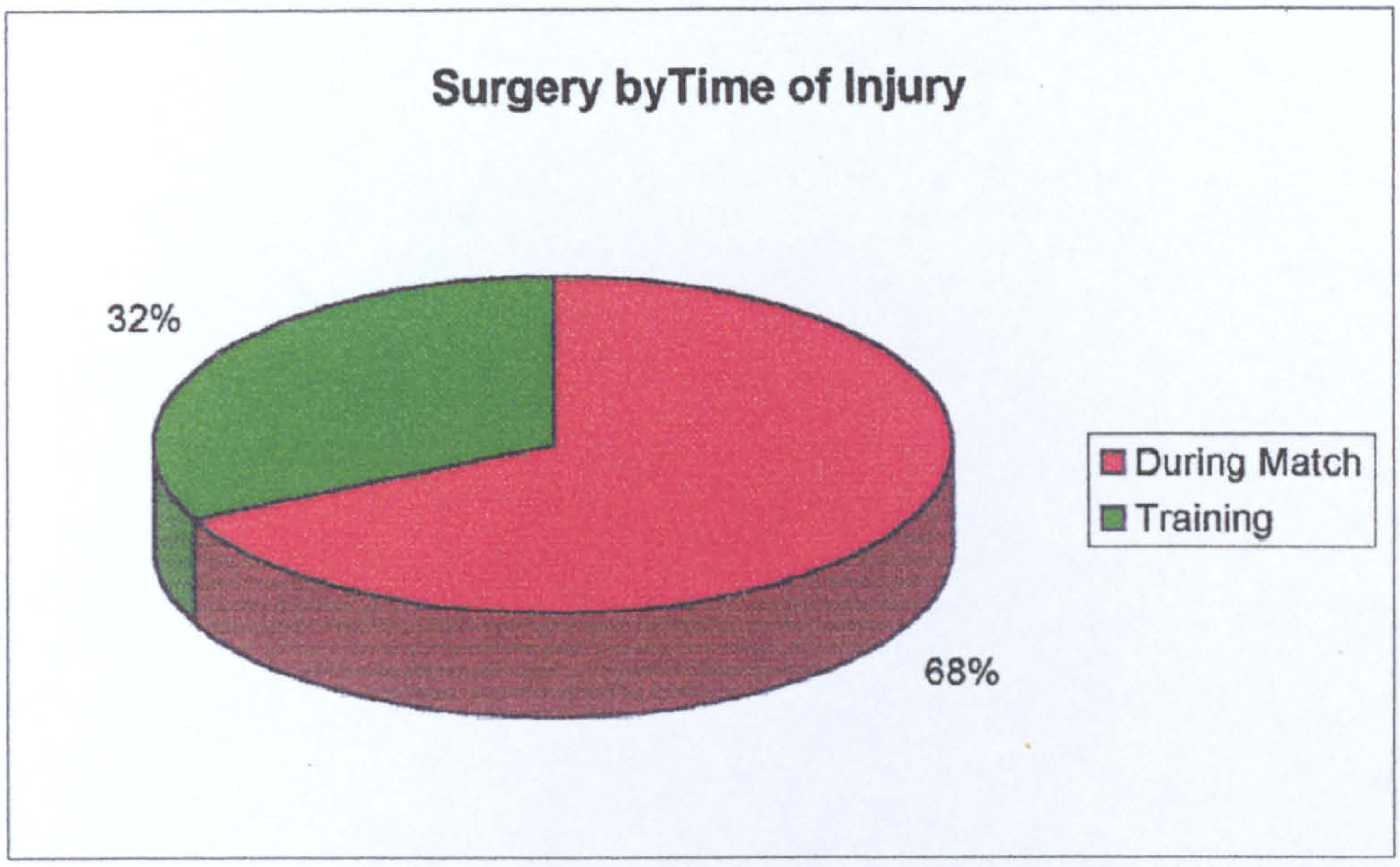
As medical science advances research is helping to improve surgical management in areas such as ligament and meniscal repair. Although this potential can be harnessed, surgery should remain a last resort and our efforts should focus on prevention.

Fig. 11.17

Sports Injury Study

Fig. 11.2

	Number of Injuries
During Match	23
Training	11



	Number of Injuries
Contact	8
Non contact	25
Total	33

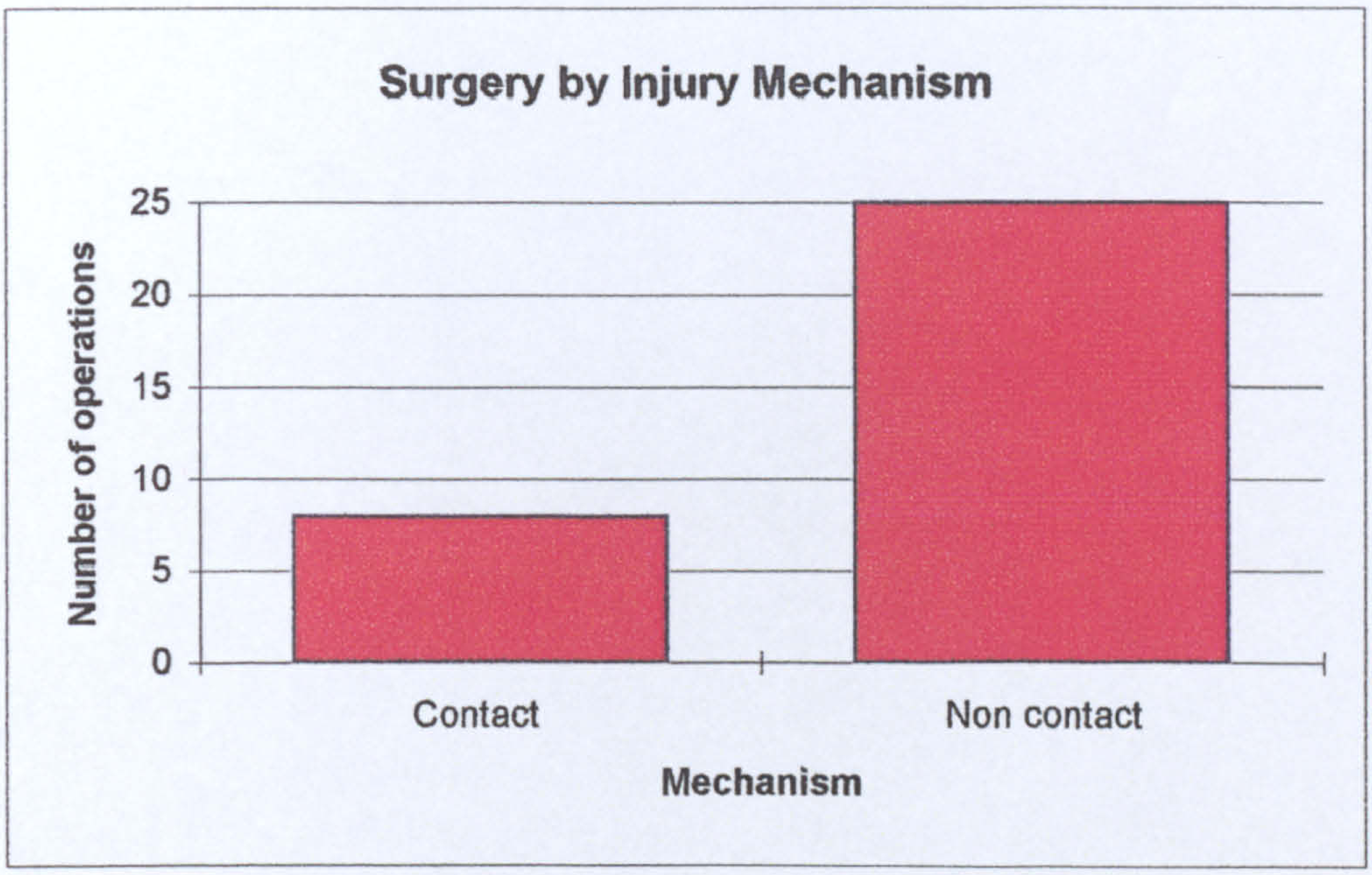
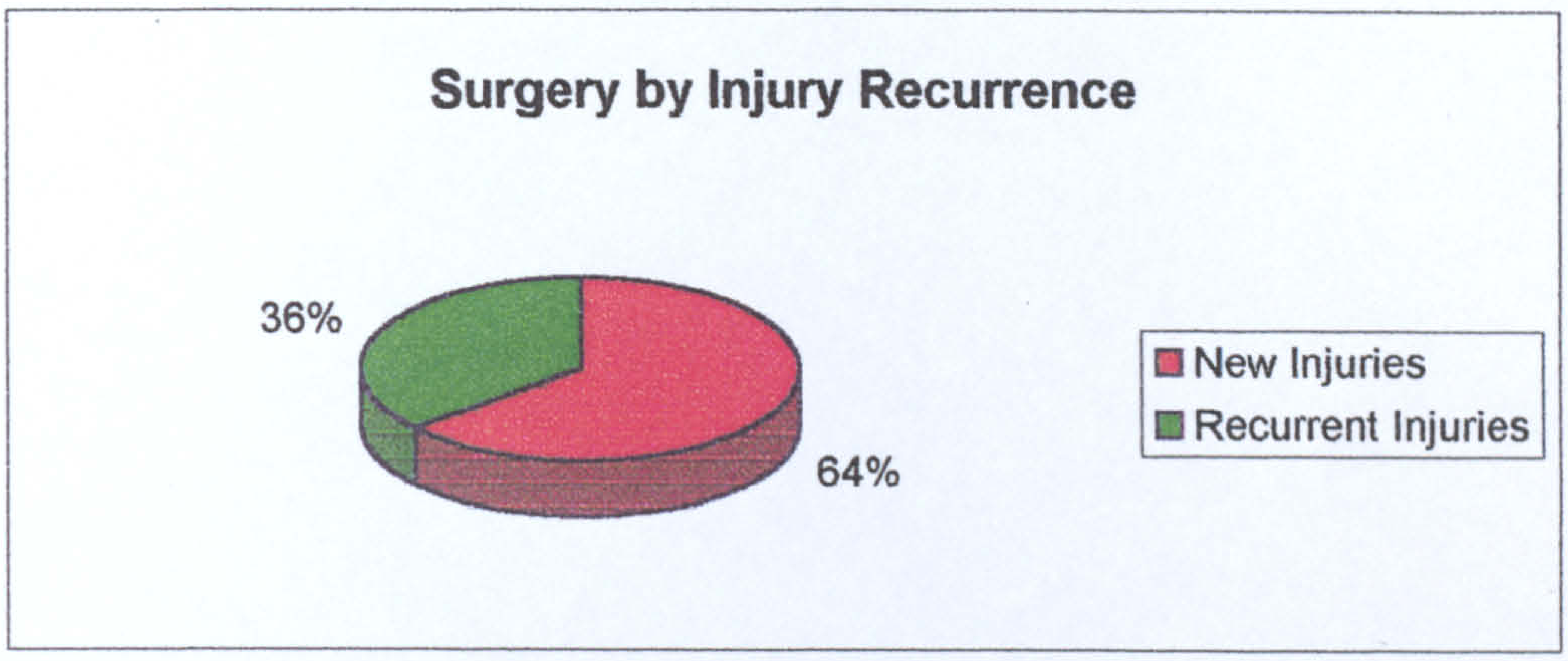


Fig. 11.3

	Number of Injuries
New Injuries	21
Recurrent Injuries	12



Numbe of players requiring surgery	30
Number of operations	33
Total number of players	342

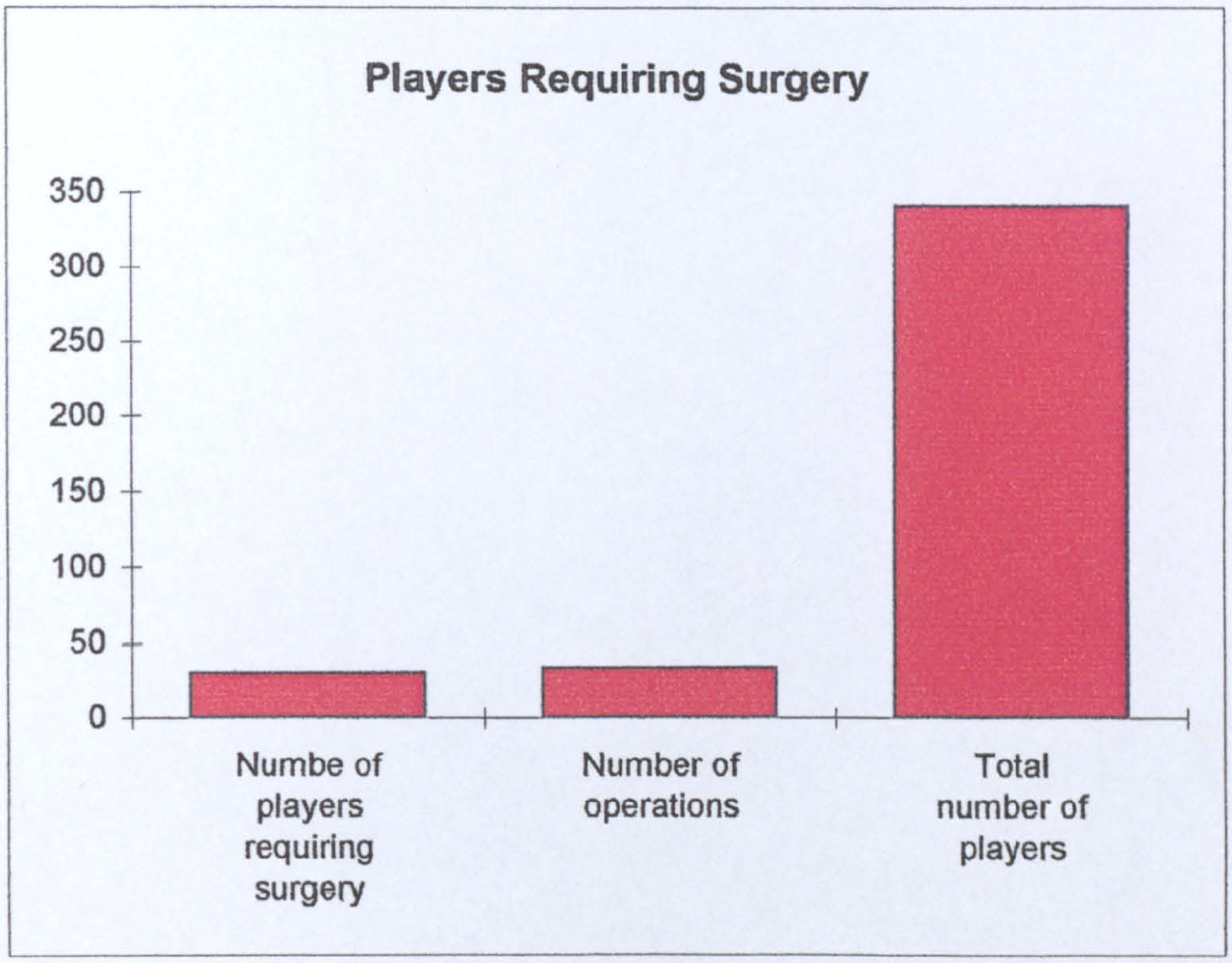
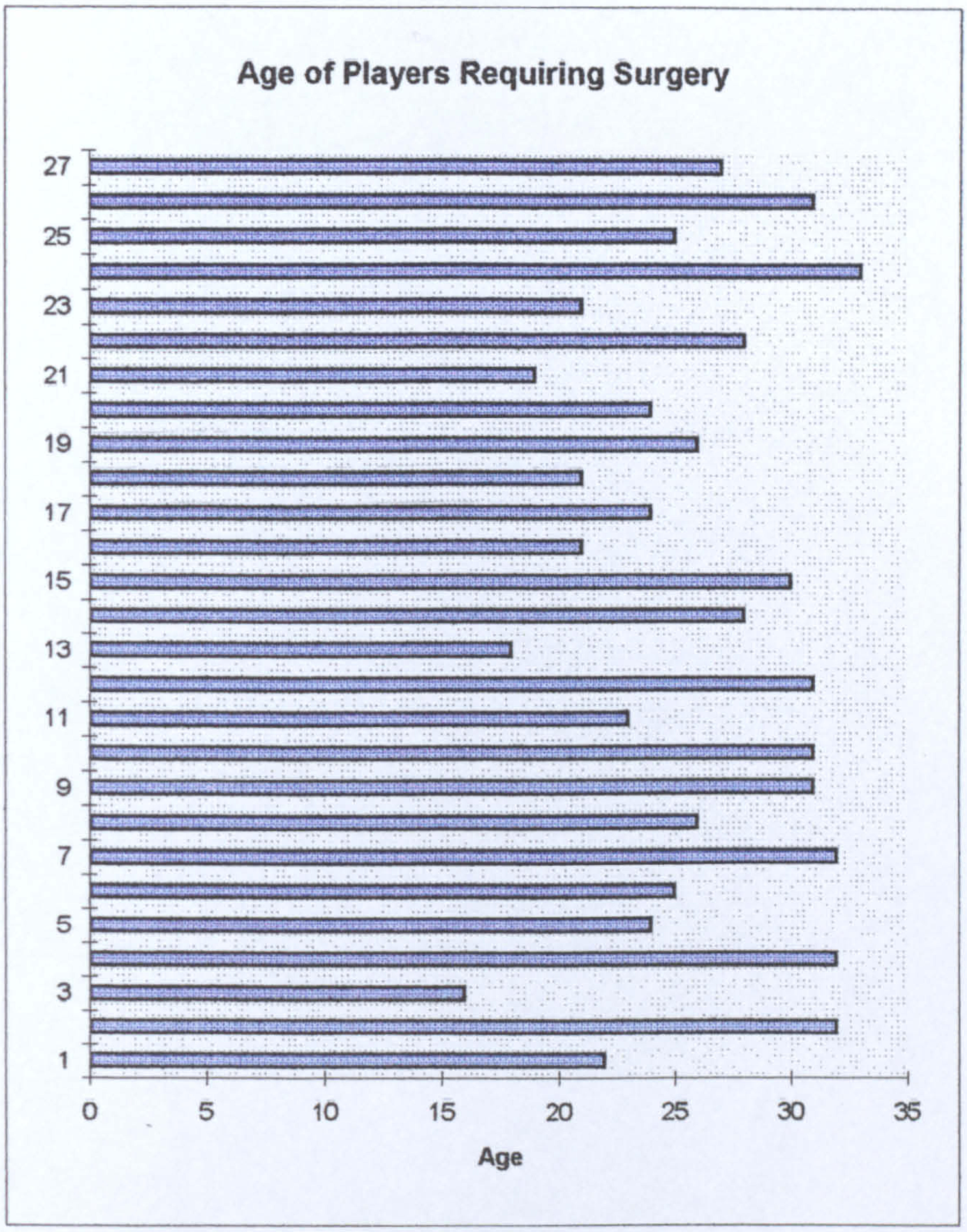


Fig 11.4



	Average Age
All Players+A18	26.01
All Players requiring Surgery	25.96

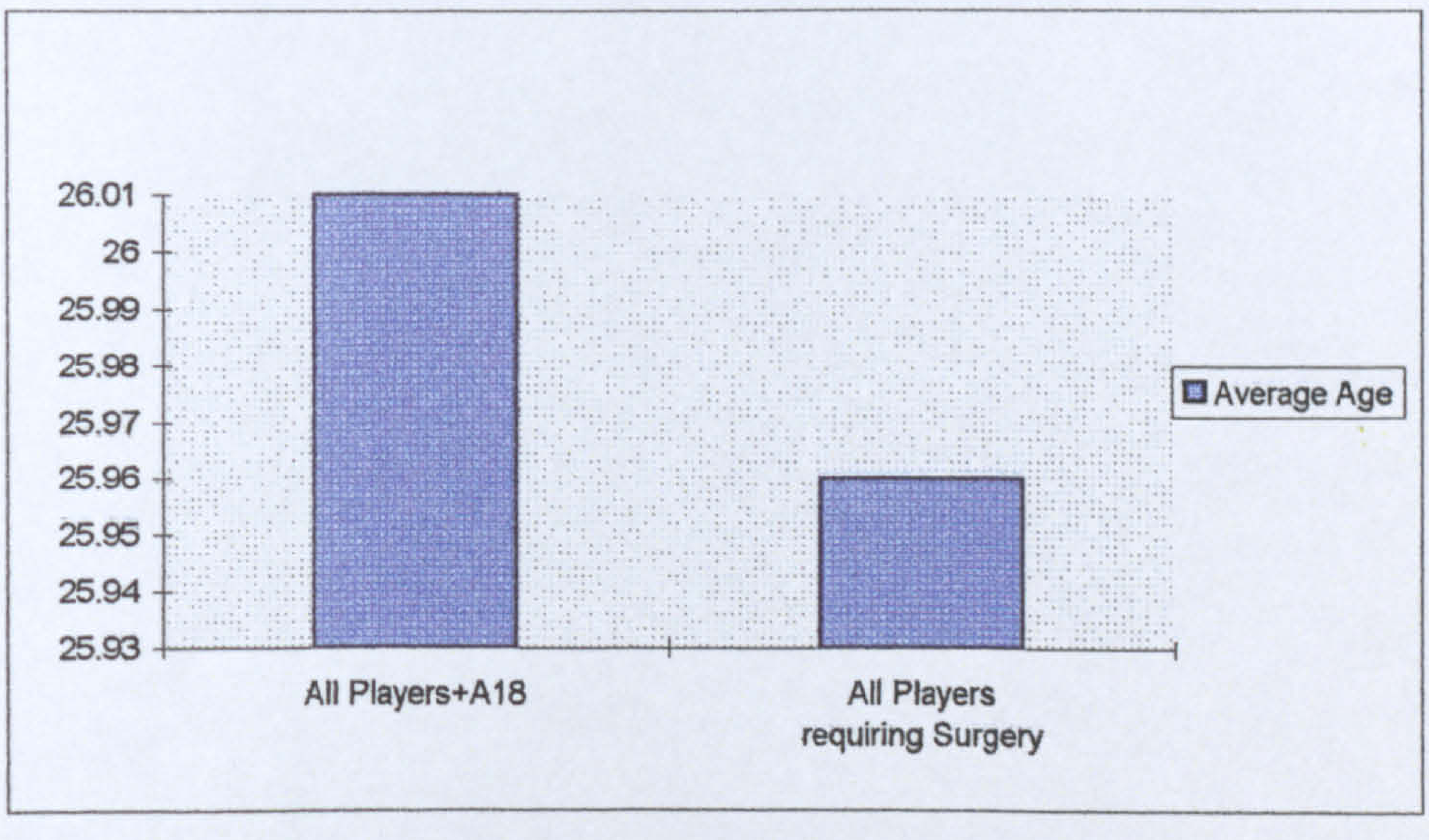
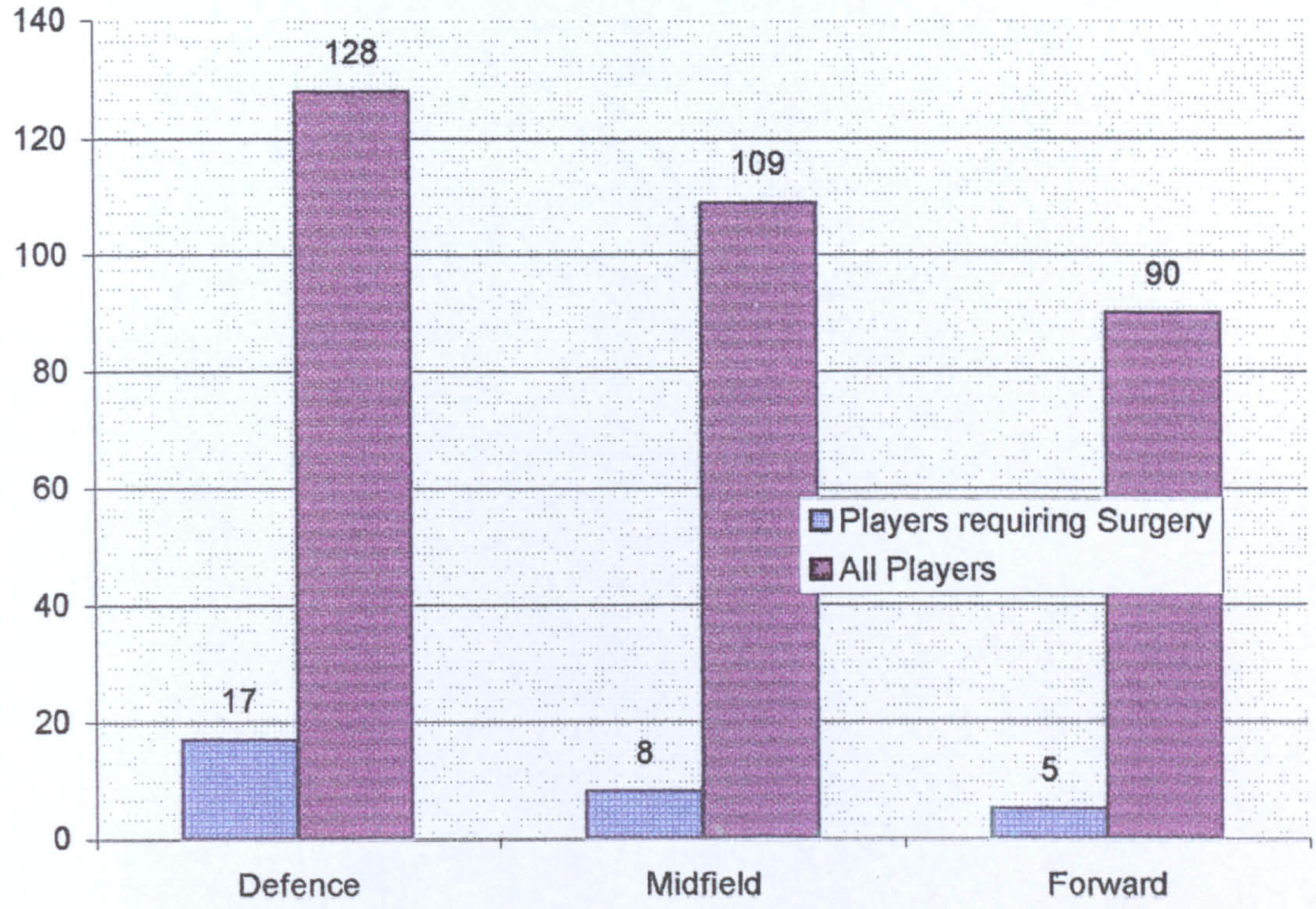


Fig. 11.5.6

Defence	17	128	
Midfield	8	109	
Forward	5	90	
Total	30	327	



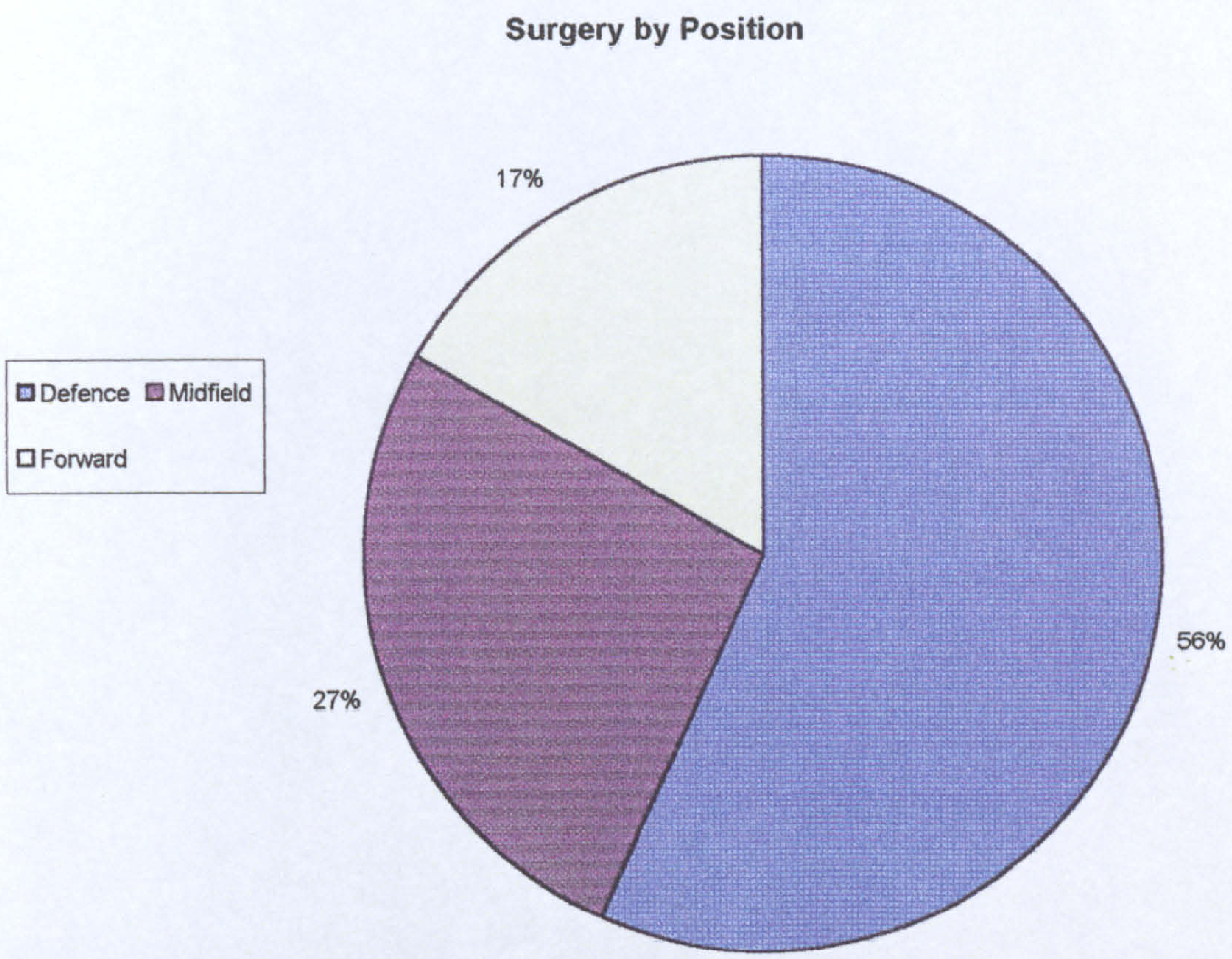
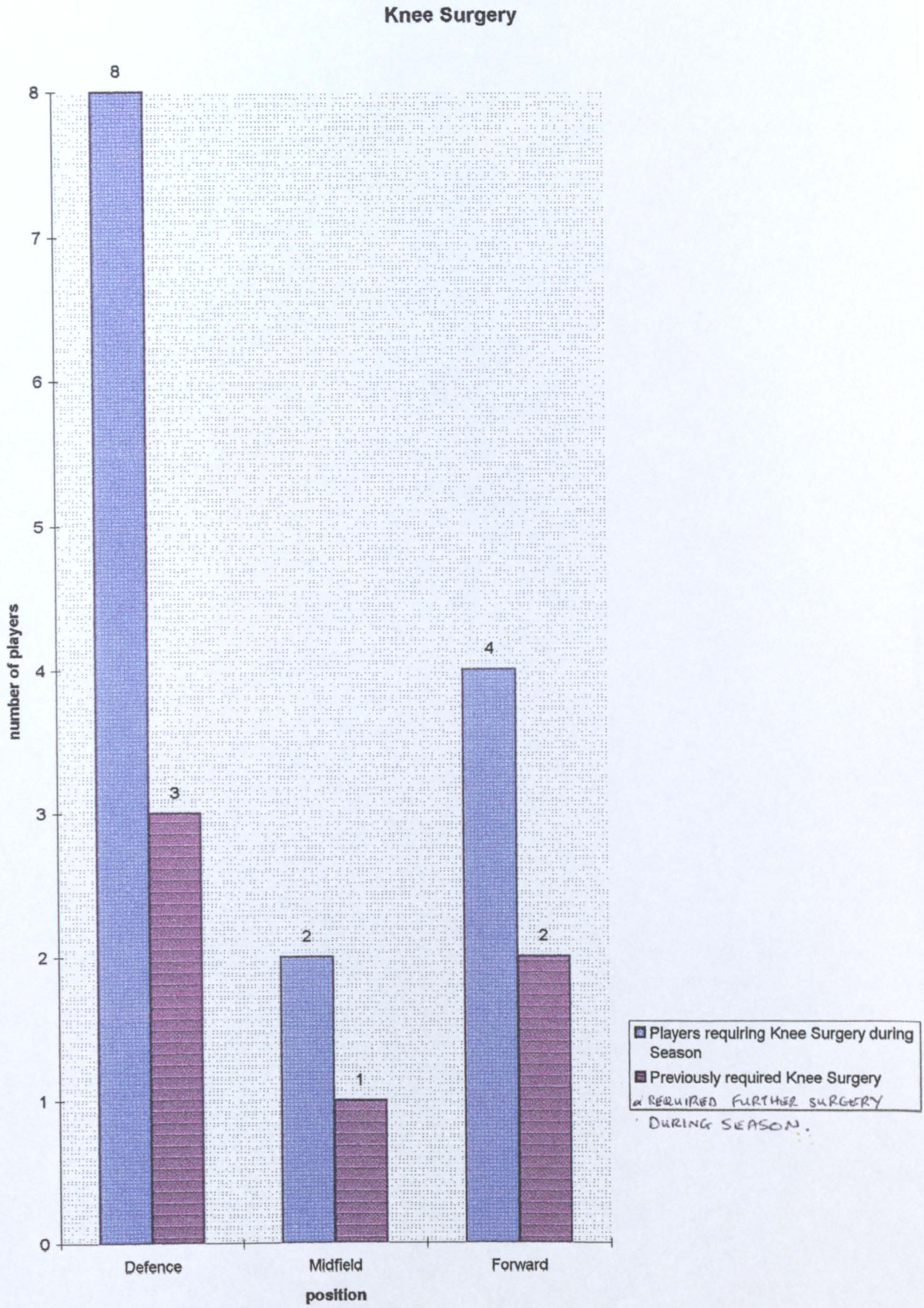


Fig. 11.6



Knee Surgery
8
3
2
1
4
2
8
7
6
5
4
3
2
1
0
number of players
Defence
Midfield
Forward
position
Players requiring Knee Surgery during Season
Previously required Knee Surgery
REQUIRED FURTHER SURGERY DURING SEASON.

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