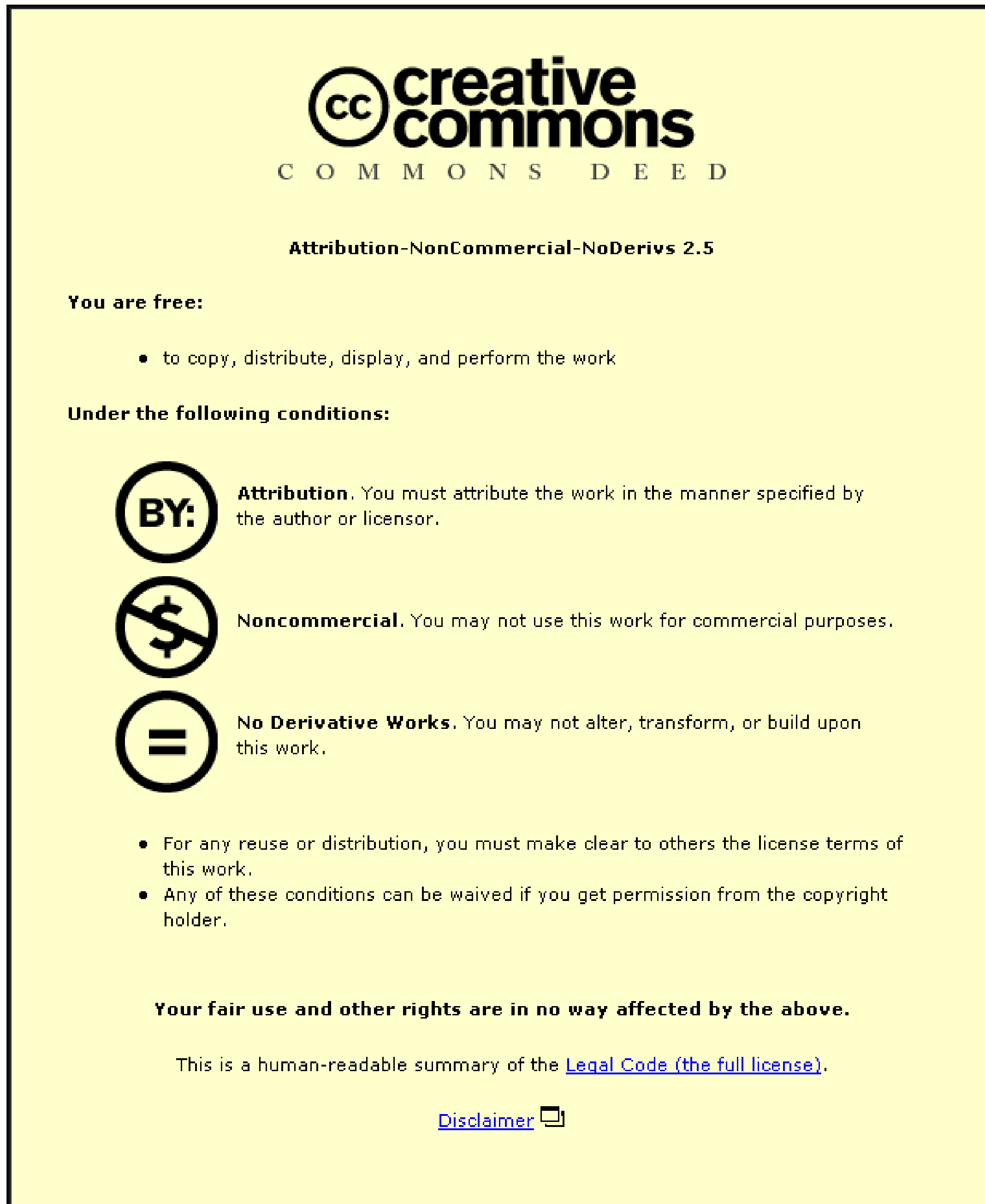


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**INJURIES IN PROFESSIONAL FOOTBALL.
IDENTIFICATION OF AETIOLOGICAL FACTORS**

By

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A DOCTORAL THESIS

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ABSTRACT

UK health and safety legislation aims to protect employees from injury at work; professional footballers as employees are therefore covered by this legislation. A risk assessment approach to health and safety issues, as required by the Management of Health and Safety at Work Regulations 1992, has been undertaken to establish the epidemiological and aetiological factors related to injuries in professional football and to identify management and training procedures to reduce the incidence and severity of injuries.

Issues of injury frequency and causation during the period 1994 to 1997 were addressed through two routes. First, during the 1994 World Cup Finals, 1996 European Championships, and 1994 to 1997 English league seasons via match analysis. Second, player injuries at four professional football league clubs were recorded by the club physiotherapist. These results provided complementary evidence showing an overall injury rate of 8.5/1000 playing hours, injury rates during training and matches being 3.5/1000 and 27.7/1000 playing hours, respectively. Two thirds of the injuries occurred during competitive match play, the remainder during training, the highest incidences of match and training injuries taking place during the first month of the playing season ($P<0.05$) and the pre-season period ($P<0.05$), respectively. The lower extremity was the site of 87% of the reported injuries, 41% and 22% of all injuries being muscular strains and re-injuries, respectively. Injury profiles differed between youth and senior players ($P<0.01$).

Additional information was recorded through an assessment of club training routines and a survey of professional footballers' knowledge and application of injury prevention strategies. Issues relating to current injury prevention practices, player's perception of injury risk and advice received relating to these issues were addressed. These results provided supportive evidence showing poor understanding of and adherence to accepted athlete training procedures and the implementation of injury prevention practices.

The studies suggest that a substantial number of injuries could be prevented in English professional football through identification of the hazards presented to players, an assessment of the existing risk levels and implementation of more rigorous control measures. Deficiencies in injury prevention practices indicate a need for wider education of players and coaches regarding the hazards and risks associated with professional football and the availability of medical and sports science knowledge to reduce these levels of risk.

Keywords: health & safety, legislation, risk assessment, football, injury, epidemiology, aetiology

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PUBLICATIONS

Unless otherwise indicated by acknowledgements or references to published literature, the work contained herein is that of the author. The findings presented in this thesis have been reported, in part, in the following publications.

Hawkins RD, Fuller CW. Risk assessment in professional football: an examination of accidents and incidents in the 1994 World Cup finals. *British Journal of Sports Medicine* 1996;**30**:165-70.

Fuller CW, Hawkins RD. Developing a health surveillance strategy for professional footballers in compliance with UK health and safety legislation. *British Journal of Sports Medicine* 1997;**31**:148-52.

Hawkins RD, Fuller CW. A preliminary assessment of professional footballers' awareness of injury prevention strategies. *British Journal of Sports Medicine* 1998;**32**:140-143.

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CHAPTER 1

INTRODUCTION

1.1 Background to the Study

Although healthy influences of sport and exercise have been comprehensively documented¹, it has become increasingly apparent that sports can present a danger to health in the form of sports injuries. In recent years there has been a considerable amount of interest in professional sportspersons and the accidents they have been subject to and the injuries they have sustained. In professional football, Nwankwo Kanu, a Nigerian international, was ordered to stop playing football at the age of 20 because of a heart condition. It was a condition that should have been identified at the start of his playing career if appropriate cardiological screening had been implemented, a screening programme which should be an integral part of the health and safety surveillance of any professional footballer. The career of Coventry City defender David Busst was brought to an end at the age of 29 following an incident that resulted in a compound fracture of the right tibia; it has been described as one of the worst injuries sustained on a football pitch². Bobby Murdoch, a former Celtic player, made legal history in 1996 after a ruling that an ankle injury received over 30 years previously was regarded as an industrial accident. In other sports, the deaths of a number of leading sportsmen have also occurred: Steve Wood, 1994 (horse racing); Aryton Senna and Roland Ratzenberger, 1994 (motor racing); Bradley Stone, 1994 (boxing); and Fabio Casartelli, 1995 (cycling).

Epidemiological studies from several countries demonstrate the significance of the sport injury problem³⁻⁵. Nicholl and Coleman⁴ estimated that each year in England and Wales there are 29 million incidents that result in new or recurrent injuries, 9.8 million of which are potentially serious new 'substantive' injuries requiring treatment and/or preventing participants from taking part in their usual activities.

It is not possible to make all sports injury free. However, the degree of risk that people are prepared to accept in sporting activities is generally higher than that which they would accept in other occupations, possibly as a consequence of the rewards available and/or the euphoric experiences encountered; this does not mean however that steps should not be taken to minimise the hazards to which professional sportspersons are exposed.

Assessments of risk in sport need to take account of the population exposed and the length of this exposure. Risk can be expressed in terms of the level and number of injuries for every thousand or hundred thousand man-hours of activity generally in terms of frequency and consequence ⁶. There are few statistics available from British research ⁷ to enable in-depth comparisons of risk between different sports to be made, however from the data available, from Britain and abroad, the highest risk of non-fatal injury has been identified as taking place in the team sports involving body contact, each sport having a specific injury profile ⁸⁻¹⁴.

It has been estimated that in association football 21 injuries occur per thousand hours of senior activity ¹⁵ or 2.7 injuries per player per season based on players being exposed for 130 hours per season; the injury rate for rugby football being of the same order of magnitude ¹⁶. In American football, a sport that has placed great emphasis on the use of protective equipment and the minimisation of injury, an overall injury rate of 0.5 per player per season has been documented ^{17, 18} which is lower than the 4.0 ¹⁹ and 1.2 ²⁰ injuries per player per season in association football. Other sports fall below this level, as shown in Figure 1.1.

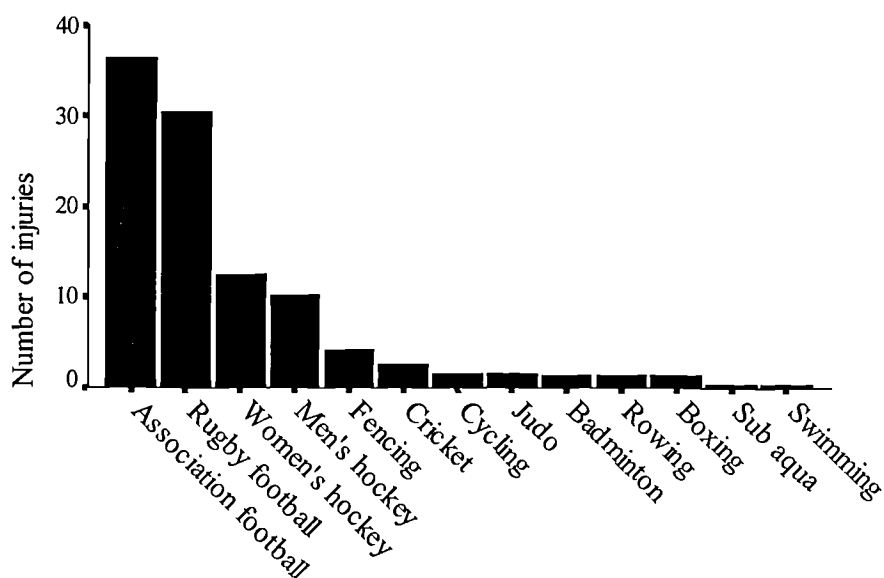


Figure 1.1: Injuries per 10,000 man-hours of play in selected sports ¹⁴.

Since association football is the most popular game in the world with the number of licensed players amounting to approximately 200 million ²¹, it is not surprising that 50-60% of all sports injuries in Europe have been estimated to be due to football where between 3.5% and 10% of all hospital treated injuries have been attributed to the sport ²². Despite this high level of injury at the professional level as well as the recreational level, an injury sustained in the sporting environment is generally treated somewhat differently from injuries and ill-health sustained through the course of other occupations. However, as was highlighted by Fuller ²³, professional

footballers are employees, and as such they are subject to the same requirements of health and safety legislation as an employee in most other occupations. UK health and safety legislation aims to protect people from injury at work, and since professional footballers are covered by this legislation, there exists a legal requirement for professional football clubs to implement proactive health and safety management. The main aim is to decrease the risk of injury or ill-health to all players, prolong their playing careers and increase their quality of life during and after their competitive playing years.

1.2 Health and Safety Legislation

Interventions in legislation intent on improving health and safety date back to the early 1800's. These were aimed at protecting the industrial worker, the first Act being passed to regulate labour in factories. It was specifically aimed at protecting the health, safety and welfare of apprentices, ensuring a yearly supply of sufficient and suitable clothing to every apprentice, prohibiting night work and excessive day time labour; it was an Act that not only addressed sanitary issues but also educational issues. It wasn't until the end of that century that health and safety legislation for the non-industrial worker appeared. From 1819 through to 1856 new regulations and statutes provided for the safety of children, young persons, and women with regards to safety, working hours, mealtimes and holidays. By 1875 a number of regulations and statutes were in existence which followed no developmental pattern, consequently a review in the law relating to health and safety in factories and workshops was undertaken by a Royal Commission. This led to the passing of the Factory and Workshop Act 1878. A similar process followed later in 1901 with further reviews resulting in the Factories Act 1937. Further changes took place leading to the Factories Act 1961 which still stands unrepealed.

Following the appointment of a committee on health and safety at work, under the chairmanship of Lord Robens in 1970, several conclusions were reached concerning the state of the legal system. The main conclusion of the Robens Committee was that the cause of many of the problems evidenced was apathy, at all levels of employment, and it was believed that people's attitudes needed to be changed²⁴. Employers and employees needed to become aware that health and safety was their concern as well as everybody else's. Several far-reaching proposals were made by the Robens Committee, the first being to devise a system whereby all employers and all employees became aware that health and safety was the concern of everyone, and not just a matter for the dedicated few, which finally resulted in the passing of the Health and Safety at Work etc. (HASAW) Act 1974²⁵ e.g. the requirements for every employer to provide such information, instruction, training and supervision as is necessary to ensure the health and safety

at work of all employees. The HASAW Act applies to all employed persons, wherever they work. In industry the act has acted as a catalyst for considerable management activity, the concern for health and safety of employees being increased due to the greater awareness of responsibility that is present.

The law on health and safety at work is an amalgam of criminal law and civil law. Criminal proceedings can be brought by the Health and Safety Executive (HSE) following breaches of a statutory provision with the accused being fined or even imprisoned. Civil claims for compensation can be brought by an injured party as a result of a failure by an employer to observe the common law duty of care.

1.3 Implications of Health and Safety Management

There are three major pieces of legislation which dominate the management of health and safety issues for all people at work, namely the HASAW Act²⁵, the Management of Health and Safety at Work (MHSW) Regulations 1992²⁶ and the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995²⁷, all of which have far reaching consequences, some implications of which are discussed below.

1.3.1 The Health and Safety at Work Act 1974

The HASAW Act applies to people, equipment and premises. Every employer is required under the Act to know and carry out the duties specified. Employers must also take into account the fact that persons not in their employment may also be affected by work activities, which requires additional duties.

The act is basically a criminal statute not giving rise to any civil liability, the general purposes of the Act being two-fold:

1. to secure the health, safety and welfare of persons at work; and
2. to protect persons other than employees against risks to health or safety arising out of or in connection with the activities of an employer.

The general duty comes under section 2(1) of the Act, where it states that '*it shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.*' To determine if something is 'reasonably practicable' a decision must

be made taking into account on the one hand the danger or risk of injury which may occur, balancing it, on the other hand, with the cost, inconvenience, time and trouble which would have to be taken to counter it. This general duty is divided into five particular duties which explain the general duty in more detail. Two examples of these are:

1. Section 2(2)(c) states '*to provide such information, instruction, training and supervision as is necessary to ensure the health and safety at work of all employees.*' This implies that information concerning the hazards involved in work and what precautions can be taken to avoid them must be given to employees, rather than waiting for it to be requested. The information provided must be accurate and meaningful to the recipients, with proper and clear instructions regarding what must and must not be done. A system of supervision which is suitable and satisfactory must be provided with properly trained and competent supervisors ensuring safety precautions are implemented, safety equipment is used and safe systems are followed. The young and inexperienced in particular must be properly supervised.
2. Section 2(2)(d) states '*to ensure the maintenance of any place of work under the employer's control in a condition that is safe and without risks to health, and the provision and maintenance of means of access and exit that are safe and without such risks.*' Thus premises must be safe and maintained in a safe condition.

Section 2(3) of the HASAW Act refers to safety policies. A commitment to health and safety at work is required by employers and is first shown by the drawing up of a safety policy, of which there is no standard or precedent to follow. A written statement of the general policy in force should be prepared by the employer with respect to:

1. health and safety of his employees; and
2. the organisation and arrangements in force for carrying out that policy.

The statement and any revisions should be brought to the notice of all employees, preferably by introducing the policy statement on an induction course and producing an information handbook rather than merely affixing a policy statement to a notice board. Employers must account for the hazards involved and the precautions and protections needed when drawing up his safety policy. Ideally it should include a general statement, indicating the commitment the management holds towards safety, clearly stating the objectives. The organisation should be set out, detailing the distribution of responsibility from the management through to the employees. The arrangements in force must be stated in relation to the objectives stated, for example, with regards to training,

supervision, safety equipment, rules and precautions. Finally a safety policy should involve periodic monitoring and revisions, adapting to any changes in law or revealed new hazards or safety problems. It is important for policies to be seen to work and to not be regarded as a mere formality.

As well as general duties being placed upon employers, duties are also placed upon employees; one of the main duties in section 7 being '*to take reasonable care for the health and safety of himself and of others who may be affected by his acts or omissions at work*'. Therefore, under this section, refusal by an employee to wear safety equipment or to take appropriate safety precautions, which are required to enable an employer to meet his legal duties, is liable to be prosecuted, as is the case if through his negligence someone else is injured.

1.3.2 The Management of Health and Safety at Work Regulations 1992

These regulations provide guidance on the application of the HASAW Act in all work activities to which the regulations apply. Generally, duties are imposed on employers by these regulations, although the self-employed and employees in certain circumstances have duties with which they must comply. These regulations do not give rise to any claim for civil liability, and are thus only enforceable by criminal sanctions, the reason being that the regulations are regarded as an extension of the duties laid down in sections 2-8 of HASAW Act 1974, which is solely a criminal statute itself. The regulations are supported by An Approved Code of Practice (ACOP) and although failure to comply with any provision of this Code is not in itself an offence, that failure may be taken by a Court in criminal proceedings as proof that a person has contravened the regulation to which the provision relates. Where criminal proceedings are taken it would be open to a person to satisfy a Court that he or she has complied with the regulation or section in some other way. Several important provisions of the regulations are discussed below.

1.3.2.1 Risk assessment (Regulation 3)

(1) Every employer shall make a suitable and sufficient assessment of -
(a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and
(b) the risks to the health and safety of persons not in his employment arising out of, or in connection with, the conduct by him of his undertaking,
for the purpose of identifying the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions.

(4) Where the employer employs five or more employees, he shall record -

- (a) *the significant findings of the assessment; and*
- (b) *any group of his employees identified by it as being especially at risk.*

A risk assessment should usually involve identifying the hazards present in any activities, followed by evaluating the extent of the risks involved, accounting for any precautions already available and used, and considering what other control measures are appropriate. The employer should then be able to decide upon what measures need to be taken in order to comply with his duties under the relevant statutory provisions. A hazard is something with the potential to cause harm and risk reflects both the likelihood that harm will occur and its severity.

The purpose of the risk assessment is to help a company to determine what measures should be taken to comply with their duties under the 'relevant statutory provisions'. This phrase covers the general duties in the HASAW Act. Regulation 3 does not itself define how to complete a risk assessment or stipulate the measures to be taken as a result of the risk assessment. Control measures will be derived from other health and safety legislation and ACOP's, taking the results of the risk assessment into account. The risk assessment therefore guides the judgement of the particular company as to the measures they ought to take to fulfil their statutory obligations.

Regulation 3 refers to a *suitable and sufficient* risk assessment: this should identify the significant risks arising out of all work activities, it should enable the organisation to identify and prioritise the measures that need to be taken to comply with the relevant statutory provisions, and it should be appropriate to the nature of the work, ensuring that it remains valid for a reasonable period of time. Reasonable steps are expected to be taken by organisations to familiarise themselves with the hazards and risks in their work. The risk assessment and the significant findings should be used positively by management e.g. to change working procedures or to introduce medium and long-term goals for improvement.

There are no fixed rules on how to undertake a risk assessment, although general principles have been outlined. It will depend on the nature of the undertaking and the type of hazards and risks present. Specialist advice may be necessary in respect of an unfamiliar risk or the assessment may be a simple process based on judgement. Separate assessment exercises may be required for different groups of people or different settings, however, a structured approach should always be adopted. The ACOP of the MHSW Regulations²⁶ suggests that a risk assessment should adopt the following approach:

- a. ensure all the relevant risks or hazards are addressed;
- b. look at what actually happens in the workplace or during work activities;

- c. ensure that all groups of employees (and others who might be affected) are considered;
- d. identify those groups of workers who might be particularly at risk; and
- e. take account of existing preventative and precautionary measures.

Once the assessment has been made, employers with more than five employees must record the significant findings of the assessment and any group of his employees identified as being especially at risk; it should then be possible to take any necessary action on the preventative and protective measures that are required. Several principles should be adopted, as suggested by the ACOP ²⁶:

- a. where possible, the risk should be avoided;
- b. the risk should be combated at source, rather than by using palliative methods;
- c. when considering the design of the workplace, the choice of work equipment and the choice of working methods, should be adapted to the individual. Where possible, monotonous work should be avoided, so as to reduce possible adverse effects on health and safety;
- d. advantage should be taken of modern technology, which is generally safer;
- e. if risks cannot be prevented or avoided, risk prevention measures should progressively reduce them;
- f. priority should be given to those measures which protect the workforce as a whole, thus yielding the greatest benefit;
- g. all workers need to understand what they are required to do;
- h. avoidance, prevention and reduction of risks should be an accepted part of the philosophy at all levels of the organisation, in respect of all its activities.

This regulation requires that companies assess the risks to their employees and also others who may be affected by their undertaking. Once the assessment has been made, the employer shall review it if it is suspected that it is no longer valid, or if significant changes in related matters have taken place. If, from a subsequent review, changes are required, they shall be implemented as soon as is reasonably practicable. Even where there is no immediate reason to believe that risks have changed risk assessments should be reviewed at regular intervals.

1.3.2.2 Health surveillance (Regulation 5)

Every employer shall ensure that his employees are provided with such health surveillance as is appropriate having regard to the risks to their health and safety which are identified by the assessment.

Four criteria have been set out by the HSE in the ACOP for the MHSW Regulations²⁶ for introducing health surveillance for people at work:

- a. there is an identifiable work-related disease or adverse health condition associated with normal activities;
- b. valid detection techniques are available to indicate adverse health conditions;
- c. there is a reasonable likelihood that the disease or condition may occur under the particular working conditions; and
- d. surveillance is likely to further the protection of the health of the employees to be covered.

The main objective of health surveillance is to detect adverse health effects at an early stage, thus enabling further harm to be prevented. In addition, the effectiveness of control measures can be checked, feedback on the accuracy of the risk assessment provided, and the individuals identified as being at increased risk protected. If providing the health surveillance is appropriate, individual health records must be kept, this being the minimum requirement.

1.3.2.3 Information for employees (Regulation 8)

Every employer shall provide his employees with comprehensible and relevant information on -

- (a) the risks to their health and safety identified by the assessment;*
- (b) the preventive and protective measures;*
- (c) the procedures for dealing with serious and imminent dangers;*
- (d) the identity of persons nominated to oversee evacuation procedures; and*
- (e) the risks which have been notified to him by another employer with whom the workplace is shared.*

It is stated in the ACOP that the information should be capable of being understood by the employees concerned, and will thus take account of their level of training, knowledge and experience. The information can be provided in whatever form is most suitable in the circumstances, as long as it is comprehensible. Relevant information on risks and on preventive and protective measures will be limited to what employees need to know to ensure their health and safety. This regulation does apply to all employees, including trainees and those on fixed-duration contracts.

1.3.2.4 Capabilities and training (Regulation 11)

- (1) Every employer shall, in entrusting tasks to his employees, take into account their capabilities as regards health and safety.*

- (2) *Every employer shall ensure that his employees are provided with adequate health and safety training -*
 - (a) *on their being recruited into the employer's undertaking; and*
 - (b) *on their being exposed to new or increased risks because of being transferred, or given changed responsibilities, or when new work equipment, new technology or new systems of work are introduced.*
- (3) *The training shall be repeated periodically where appropriate, adapted to take account of new or changed risks, and it should take place during working hours.*

Through training, competence is achieved and information is converted into low risk practices, contributing to the health and safety culture of an organisation at all levels. From the risk assessment the level of training required can be determined, forming part of protective and preventive measures, possibly including basic skills training and on-the-job training. The ACOP suggest that training needs are likely to be greatest on recruitment, new employees receiving basic induction training on health and safety matters, with particular attention being given to the needs of young workers. Training should be repeated periodically if particular skills are used infrequently to ensure continued competence. To establish a suitable period for re-training results from health and safety checks, accident investigations and near miss incidents can be used.

1.3.3 The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995

A complete system for the notifying and reporting of injuries, dangerous occurrences and industrial diseases is laid down in RIDDOR²⁷. A specified incident is required to be notified to the enforcing authority by the quickest practicable means and reported to the enforcing authority in writing within ten days. It is not only employees to whom the requirements relate, but to persons on work training schemes, self-employed persons and non-employees who are affected by work activity. Several events are reportable when suffered as a result of an accident arising out of or in connection with work, some of which are listed below:

- (a) *the death of any person;*
- (b) *(i) fracture of the skull, spine or pelvis;*
 - (ii) *fracture of any bone,*
 - (a) *in the arm or wrist (but not a bone in the hand);*
 - (b) *in the leg or ankle (but not a bone in the foot);*

- (iii) *amputation of a hand or foot, or a finger, thumb or toe (if the joint or bone is severed);*
- (iv) *loss of the sight of an eye, a penetrating injury to the eye, or a chemical or hot metal burn to the eye; and*
- (v) *any other injury which results in the person injured being admitted immediately into hospital for more than 24 hours.*

Incidents also reportable are injuries whereby any person at work is incapacitated from his normal work for more than three days caused by an accident at work. It is viewed that if a person attends work after the accident, but, being unable to do his normal job, is given alternative ('light') work, that accident is still reportable.

Under the regulations employers are required to keep records of all events reported; since no specific design is required this record may be kept in the form of photocopies of accident report forms, an accident book, or stored electronically. In the case of a reportable accident or dangerous occurrence, the date and time of the incident, the name, occupation and nature of any injury, the place where the injury or dangerous occurrence happened and a brief description of the circumstances must be contained in the record.

1.4 Sport and the Law

There are a large number of injuries in most professional sports every year, and it is only in recent years that the interest in accidents and injuries suffered by professional sportspersons has increased. Previous research has in the majority been centred around the medical aspects of injuries; however, it should be recognised that health and safety legislation applies to professional sport just as it does to other industries. It is important, as with any other occupation, to understand the underlying causes of the incidents leading to the injuries and to take steps to minimise future injuries. The introduction of the MHSW Regulations²⁶ formalised a risk assessment approach to health and safety issues; an approach that has always been implicit in the HASAW Act²⁵. RIDDOR²⁷ is a further important legislative document, one purpose being to provide reports to the HSE or the Local Authority of any event resulting in accidents at work.

1.4.1 Health and Safety Legislation and Professional Football

The HASAW Act places duties of a general nature on employers, employees, the self-

employed, providers of workplaces and manufacturers of work equipment. The professional footballer is an employee and, as such, there are several relevant important sections contained in the Act. The legislation states under *Section 2, 'General duties of employers to their employees'*, that 'it shall be the duty of every employer to ensure, *so far as is reasonably practicable*, the health, safety and welfare *at work* of all his employees'. For the professional footballer, as with the majority of other sports persons, time *at work* is mainly attributable to time spent training and in competition. The term *so far as is reasonably practicable* is not defined in the Act; however, its meaning has been established in case law. The HSE²⁸ and the law courts accept that the statement means:

'the degree of risk in a particular activity or environment can be balanced against the time, trouble, cost and physical difficulty of taking measures to avoid the risk. If these are so disproportionate to the risk that it would be unreasonable for the persons concerned to have to incur them to prevent it, they are not obliged to do so'.

Employers must demonstrate that they have identified the hazards involved with football and assessed the risks associated with these hazards. They have an obligation to make the necessary resources available to reduce those risks, whether it be to provide adequate training facilities, implement low-risk training procedures, or educate the players on the benefits of a high carbohydrate diet, since the responsibility for preventing injury and ill-health rests with those people who give rise to the risk. Unless employers have carried out this duty they can not demonstrate that their actions fit the description *so far as is reasonably practicable*.

This general requirement for risk assessment is a specific requirement of the MHSW Regulations²⁶. Regulation 3 requires every employer to make a *suitable and sufficient assessment* of risks to the health and safety of employees and other people affected by their activities. To satisfy this requirement it is important that the employer is aware of the hazards and risks to which a footballer is subjected and to define and implement management systems to minimise the risk of injury and ill-health. An employer is expected to provide the footballer with the necessary information on possible injuries and ill-health arising from the sport and then to provide adequate training and supervision to minimise the risk of injury or ill-health.

Under the HASAW Act employers have a general duty to persons other than their employees. Employers must ensure, *so far as is reasonably practicable*, that persons not in their employment are not exposed to risks to their health or safety. With regards to football, this implies that the team tactics employed should not put the health and safety of the opposing team

at risk. Many of the laws of the game of football are in fact included to reflect, and minimise, the risk of injury or ill-health. If a particular action has been identified as commonly leading to the injury of a player then the ruling body should change the laws of the game to make the action unacceptable. A ruling has been implemented by the International Federation of Football Associations (FIFA) over recent seasons with regards to tackling players from behind, however, the evidence on which this ruling was made has not been documented.

Employees also have a general duty at work. There is a legal responsibility defined for employees to not only ensure that they do not put themselves at unnecessary risk of injury but also to ensure that they do not put any other person at risk of injury. The implication here is that provided a footballer performs within the laws of the governing body it can be considered that reasonable care is being taken of their own and others health and safety. However, if there is a transgression of the laws of the game, and it is reasonably foreseeable that an injury to a player would result from that transgression, then there is a breach of this section of the Act.

The HASAW Act specifically excludes civil liability for a breach of any of the general duties required under the Act as previously mentioned. Therefore, if a player is injured during competition or training and wishes to claim for compensation their only option is to bring a civil case against an employer, fellow competitor, equipment supplier, etc.. In this case, it is necessary for the injured player to demonstrate a failure by the defendant to show a duty of care to those with whom he came into contact. There has been an increase in the willingness of the player to consider this option using the torts (breaches of duty leading to liability for damages) of negligence and assault. In the case of *Saunders vs Elliott* in 1994, Elliott attempted to sue Saunders over a tackle, made in September 1992, which ruptured his knee ligaments and has prevented him from playing since²⁹. However, in this case the court ruled against Elliott and no damages were awarded since it could not be proven that the injury was caused intentionally or by reckless disregard.

Other general duties under the HASAW Act include the responsibilities which persons concerned with the premises have towards the players and spectators. A player can reasonably expect to have a playing area where the level of risk of injury or ill-health is reduced *so far as is reasonably practicable* to a minimum, eliminating potential hazards that may arise, for example, from colliding with advertising hoardings, or as a result of the pitch conditions.

RIDDOR 1995 could have the greatest impact on professional football if the regulations were fully implemented. These regulations²⁷ apply to events that arise in connection with work activities covered by the HASAW Act and they, therefore, apply to all professional sports. The

original intention of RIDDOR was that injuries arising from violence at work should be classified as reportable: this aspect of injury at work has only recently been implemented. Injuries arising from acts of violence are now reportable if they fall into the specified categories since an 'accident' has been defined as including '*an act of non consensual physical violence done to a person at work*'. Injuries arising from some occupations, in particular some professional sports such as rugby and boxing, are excluded since a level of risk of injury during their normal course of events is accepted. This same level of consensual violence should not apply to football and therefore, the implications for professional football, as with other sports and occupations, of reporting an injury as arising from an act of violence and the consequential possibility of civil legal proceedings are most significant.

Under RIDDOR *Regulation 3, 'Notification and reporting of injuries and dangerous occurrences'* it has already been described how the enforcing authority is required to be notified and the events to which this applies. There are many sports where accidents occur leading to injuries of the type described above and these injuries should be reported to the appropriate authority.

The responsible person is also required to report cases 'where a person at work is incapacitated for work of a kind which he might reasonably be expected to do, either under his contract of employment, or, if there is no such contract, in the normal course of his work, for more than 3 consecutive days'. This sub-section of the Regulation 3 requires any 'over 3-day' accident to be reported and would include the case where a footballer can not carry out his normal training programme as a result of an injury even though he may still be available for the next scheduled competitive match.

1.4.2 Health and Safety Management in Professional Football

Professional football clubs who manage health and safety successfully should have their health and safety risks under control and be able to demonstrate a progressive improvement in their injury record. In order to achieve this several principles must be adhered to, forming a foundation on which a successful health and safety management system can be established.

To be successful in achieving high standards of health and safety, professional football clubs need to have health and safety policies which contribute to their business performance, which is a consequence of their playing performance, while meeting their responsibilities in a way that fulfils both the spirit and the letter of the law. The expectations of playing staff, backroom staff (managers, coaches, physiotherapists, doctors, sport science support staff), shareholders,

supporters and visitors should all be satisfied. Their policies should be cost effective and aimed at developing human resources and reducing financial losses and liabilities. Their health and safety policies influence all their activities and decisions, including those to do with the selection of players, training methods employed, and the condition of the working environment.

In order to achieve high health and safety standards, professional football clubs should be structured and operated so as to put their health and safety policies into effective practice. A positive culture should be created securing the involvement and participation at all levels, on and off the playing and training areas. Effective education and the promotion of competence will enable employees to make a responsible and informed contribution to their own safety as well as the health and safety of others. Managers and coaches should display a visible and active example which is crucial to the development and maintenance of a footballing culture supportive of health and safety management. It is the vision, values and beliefs of the people in charge that become the shared knowledge of all involved in the club.

A successful club needs to adopt a planned and systematic approach to policy implementation. Risks as a result of working activities should be minimised. Priorities are decided and objectives for hazard elimination and risk reduction set by using risk assessment methods. Standards of performance are established against which performance is measured. Specific actions needed to promote a positive health and safety culture and to eliminate and control risks should be identified. Hazards are eliminated wherever possible through the selection of playing areas, equipment and training procedures but if this is not possible then the risks arising from those hazards should be minimised.

Health and safety performance in clubs, which manage health and safety successfully, is measured against pre-determined standards. This reveals when and where action is needed to improve performance. The success of any action taken to control risks is assessed through active self-monitoring involving a range of techniques, including an examination of both hardware (training and playing areas, players equipment) and software (playing and training procedures), and individual player's behaviour. Reactive monitoring, which assesses failures of control, requires the thorough investigation of any accidents, ill health or incidents with the potential to cause harm or loss. The objectives in both active and reactive monitoring are not only to determine the immediate causes of sub-standard performance but to identify the underlying causes and the implications for the design and operation of the health and safety management system.

An important element in health and safety management is applying the lessons learned from all

relevant experience. There should be a systematic approach through regular reviews of performance assessed from audits and monitoring activities. These form the basis for self-regulation and for securing compliance with Sections 2 to 6 of the HASAW Act²⁵. Constant development of policies, approaches to implementation and techniques of risk control is required for a commitment to continuous improvement. Football clubs that achieve high standards of health and safety will assess their health and safety performance by internal reference to key performance indicators and by external comparison with the performance of rival clubs. They should also record and account for their performance in an annual report.

Football is one of the many sports where a risk assessment approach to health and safety issues, as required by the MHSW Regulations, would highlight areas needing improvement. There are real benefits to everyone associated with sport at all levels. The benefits are: the athlete's risk of injury or ill-health will be reduced; the employer's assets will be maintained and spectators' enjoyment will be increased from having the opportunities to see top players competing in more games.

Most occupations have seen an improvement in the health and safety of the workforce as a result of implementing proactive health and safety management. There is no reason to suggest that professional football would not benefit in a similar way. In achieving excellence in professional football with regards to player development, the input of sports science and sports medicine into playing and training is crucial; it would not be possible to apply the concepts of health of safety management without integrating sport science experience. From a legal perspective athletes must be warned of the inherent risks of their sport, being taught the skills to enable them to face and deal with those risks safely. Coaches must also ensure that their athletes possess adequate physical and mental skills to enable the required tasks to be performed; if athletes are not evaluated for injury and incapacity coaches run a serious risk of liability. It is necessary therefore for coaches to remain informed. For example, if training methods and techniques advance and a coach continues to use the 'old' methods, they do face the prospect of liability. In order to implement control measures for the control of risk in professional football an understanding of sports science is required.

1.5 Injuries in Professional Football: Sports Science and the Implementation of Control Measures

The first step in instituting a programme of injury prevention is recognising the true relationship

between injury and the potentially provoking activity. Some degree of relationship may be immediately apparent but its extent and significance is often hidden unless scientific methods are used for its evaluation. It is clearly impossible to legislate for and prevent every possible catastrophe in any activity that may cause injury, therefore practical considerations invoke the law of diminishing returns.

After accepting that injury is a likely consequence of many sporting activities it becomes necessary to assess the anticipated level of injury in terms of both quantity and quality. Therefore, the first step in injury prevention lies in recognising that there is a problem, and in defining the extent of that problem in both quantitative and qualitative terms. A study of injuries and its mechanisms should be properly undertaken, and the mechanisms properly understood.

The acceptability of methods of prevention of injury depends to some extent on the perceived level of risk. It may often be necessary to educate participants in sport that there is a significant level of risk that has to be reduced. Generally, however, governing bodies have tended in drawing up rules of sport to seek measures to prevent injuries being caused to others (e.g. equipment - studs; referee - dealing with offences such as fouls from behind), being less concerned with the prevention of self-injury. In the remainder of this section the epidemiology of football injuries is discussed together with aetiological risk factors reported in the literature.

1.5.1 Injury Epidemiology

The current literature on the epidemiology of football injuries shows conflicting data with regards to the incidence, severity and aetiology of injuries^{30, 31}, however, some discrepancies may be explained by the different methodologies employed by the researchers and the different definitions of injury used.

Definition of injury

No common operational definition of football injury currently exists, different definitions having been used in various epidemiological studies; comparisons between studies are therefore difficult. A variety of definitions have been used to date, a football injury being defined as one for which an insurance claim is submitted³²⁻³⁸, and that treated at a hospital casualty department^{3, 33, 39-52}. There are problems associated with these definitions however, one being that the population at risk is unknown and another that the more serious and acute injuries are predominantly recorded, most likely missing the overuse and less serious injuries. On the other extreme McMaster and Walter¹⁹ and Nilsson and Roaas⁵³ recorded every injury reported by the athletes, possibly degrading the data with a lot of minor injuries such as blisters and abrasions. It

is important though that both types of injuries are included in any analysis since Ekstrand and Gillquist⁵⁴ showed that one third of the moderate and major injuries occurred within two months of a minor, and several authors have reported a third of the injuries sustained by senior players to be overuse^{20, 55-58}. It has been suggested by several authors that time loss from practice and games should be used⁵⁹⁻⁶¹. This is a more functional approach, lost practice or playing time possibly identifying those injuries which have the severest effect on the club and also the players' health and performance.

Data concerning the risk of injury and incidence during football is only as meaningful as the definition of injury used during that study. Injuries must be defined so that they can be recognised, ensuring that the definition is clearly explained and understandable. A universal operational definition of football injury is indeed required to enable the comparison of future football injury studies to be made, and also comparisons with other sports. Keller et al.⁶¹ suggest that only those injuries resulting in lost time from practice or play should be included in any statistics, the definition of injury being based on health rather than illness, athletes not being fully recovered if they cannot take part in regular training for their sport or competition. The National Athletic Injury Registration System (NAIRS) in the United States⁶², and the Council of Europe⁶³ use the following definition: 'A sports injury is one which occurs as a result of participation in sports and limits athletic participation for at least a day after onset.' The duration of the restriction from athletic performance should also be reported which naturally follows on from this, enabling a useful measure of the severity of injury to be made.

Incidence of injury

The incidence rate of football injuries can be defined as the number of new football injuries during a particular period divided by the total number of footballers at the start of the period. Without the denominator the risk of injury cannot be calculated and assumptions about risk cannot be made⁶⁴. It is important for exposure to be accounted for, enabling a true injury rate to be reached, many studies having expressed the number of new injuries per 1000 hours of participation^{11, 15, 53, 55-57, 65-73}, allowing for a comparison of the risk of injury between different sports.

Sandelin et al.³³ recorded 2072 injuries from a total of 35500 registered footballers, resulting in an annual injury rate of 5.8%. Different rates have been documented, Sullivan et al.⁶⁷ and Pritchett³⁶ finding values of 2.6% and 4.1%, respectively, from football in the United States. Similar figures to Sandelin et al.³³ were reported by Schmidt-Olsen et al.⁶⁹, the authors reporting that 5.2% of 6600 9-19 year olds suffered from a football injury.

The risk of injury between different activities within football has been found to differ. This is calculated by dividing the number of new injuries arising from a particular activity by the number of players exposed and time spent on the particular activity. Several studies have considered the risk of injury in games as well as training^{11, 15, 55-57, 71, 73}, the risk during games having been reported as being 3 to 4 times greater than that seen during training. However, the injury incidence during a pre-season period at a training camp was found to be almost three times the level of risk reported for training during the competitive season ($21.3 \pm 15.2/1000$ hours vs $7.6 \pm 2.1/1000$ hours)¹⁵. As already indicated there are difficulties in making comparisons due to the study designs and definitions of injury used. For example, Schmidt-Olsen et al.⁶⁹ found an injury incidence of 19.1/1000 playing hours, however if slight injuries were not considered in the 5 day youth tournament the rate would have been reduced to 9.4 injuries/1000 playing hours.

There are several factors influencing the accuracy of the incidence of injury calculated, particularly the definition of injury used, the way by which the incidence is expressed, the method of injury documentation used, the means by which the population at risk is established and the representativeness of the research sample. Ideally, knowledge of the exposure of the population to injury is required rather than having to draw conclusions from data on injured players alone. The data should also be collected in a prospective manner rather than retrospectively due to inconsistencies in medical records, attendance records and memory bias; data collected retrospectively using a period of 30 weeks or more is considered to be unreliable⁷⁴. The injury definition used should follow that of NAIRS⁶² since the length of practice/playing time lost is important to both player and club. Injuries should be diagnosed by qualified medical staff rather than by coaches or the players themselves, this latter method of injury reporting having been used by several researchers^{72, 75}. Finally, the representativeness of the study population is dependant on aspects of selection, where ideally the whole population to which the research will be applied is part of the sample. However, this is very rarely possible and traditional sampling methods should therefore be implemented. Failing this, biases need to be identified and consequently caution should be taken when applying the results of studies to different populations to which the studies utilised since there are many factors having been identified to influence the incidence of injury.

Other influential factors of injury incidence reported are age, playing position and level of play. The injury incidence during football does appear to increase with player age^{66, 67, 69, 72, 76}. A 100-fold difference has been shown between youth and professional leagues, Sullivan et al.⁶⁷ reporting 0.03 injuries per player per season versus 4.0 and 1.2 injuries per player per season reported by McMaster and Walter¹⁹ and Albert²⁰, respectively. It is important to note however that these results are absolute values and reflect the injury risk from playing football and

exposure to it since the amount of time spent training and playing varies at different levels. Based on the incidence of football injuries per 1000 game hours, senior male players sustain more injuries than youth ^{11, 15, 55-57, 66, 71, 72, 75}. Possible explanations for the increased injury incidence in older athletes include the increased ball and body momentum, more intense and competitive style, aggressive play and greater risk-taking behaviour ⁷⁰. Support is given by the injury rate reported among youths aged 12-19 in the Norway cup ⁵³ being twice that by youths aged 7-12 in an Oklahoma league ⁶⁷, and injury rate among senior players in games was more than twice that found during practice ^{15, 54, 58, 77}. Therefore, it appears that intensity is important and possibly explains injury increase with age. Younger athletes are generally less skilled, they don't perform high risk tasks, their intensity is less as is their body size, speed and momentum, therefore smaller impact forces on collision are produced. How these all affect injury rate though are unknown, thus requiring more epidemiological studies on these issues. It is not clear that an inverse relationship exists between skill and injury; Keller et al. ⁶¹ postulate that greater ball control leads to greater time of ball possession, thus the opportunity for non-contact activity and defensive interventions, increases the chance of injury.

The relevance of players' position to the incidence of injury has been considered in several studies ^{19, 20, 33, 67, 68, 77, 78}. It is important to consider when interpreting the incidences of injury by position that players are unequally distributed amongst them. The flow of the game and the formation selected must be taken into account, some studies having assumed a 3-3-4 formation ^{19, 67} and others 4-3-3 ^{15, 54, 58, 77}. Albert ²⁰ found defenders to be a high risk group for major injuries and goalkeepers to have a high percentage of upper limb injuries. Similarly Jorgensen ⁶⁸ reported goalkeepers and defenders to have a significantly greater incidence of injury than attackers. Several authors have expressed concern regarding goalkeeping injuries with both Sullivan et al. ⁶⁷ and Wilkinson ⁷⁹ finding a higher susceptibility to injury among them, stressing the need for more intensive supervision by the referee around the goal. Not all studies have reported differences between positions however; Sandelin et al. ³³ and Peterson and Renstrom ⁷⁸ found no difference in the spread of injuries between positions. This was also the case in a study of Swedish senior men ^{15, 54, 58, 77} and the study of McMaster and Walter ¹⁹ on professional players.

With regards to the level of competition, significantly ($P < 0.001$) more injuries were found to occur in the top two divisions in Norway compared to the lower ones in a study by Sandelin et al. ³³, complementing the results of Roaas and Nilsson ³². Nielsen and Yde ⁵⁵ and Ekstrand and Tropp ⁷¹ also found an increase in playing level lead to an increase in match injuries, whereas a decrease in level led to an increase in practice injuries; however, no statistics were available to corroborate this. Suggested explanations for these differences were based around the intensity

and speed of the game, physical characteristics of the players and the teams' training conditions. No differences between the players in different Swedish divisions and their incidence of injury were reported by Peterson and Renstrom⁷⁸. Again it is important to stress the need for exposure to be accounted for when interpreting these results, for example, the incidence of ankle sprains was not found to differ between different levels of senior football when exposure was taken into account⁷¹.

Nature of injury

The classification of sports injuries was first suggested by Thorndike⁸⁰ and presented by the American Medical Association⁸¹ and Williams⁸². The following categories of medical diagnosis are currently used: sprain (of joint capsule and ligament); strain (of muscle and tendon); contusion (bruising); dislocation or subluxation; fracture (of bone); abrasion; laceration; infection or inflammation; concussion. As previously mentioned a study design does have a bearing on the nature of injuries; e.g. the predominantly serious acute injuries are observed where insurance claims and hospitals are used to record injuries, missing overuse and less serious injuries - this is shown by the high percentage of fractures in several studies^{36, 39, 40, 43, 52}.

Strains, sprains and contusions account for most of the injuries, ligament sprains representing around one-third of the injuries independent of age or level of competition. In professional and senior players however, compared to youth players, muscle strains represent between two and four times greater proportion of injuries. Jorgensen⁶⁸ even reported muscle strains to be the most common injury in 30-33 year olds, having twice as many compared to other groups. A higher percentage of strains has also been reported in professional football compared to the senior amateur level^{20, 54-56, 83}. Youth players, however, sustain more contusions than do senior players^{19, 20, 53-57, 69, 83, 84}. It has been suggested that injuries resulting from contusions may not be tolerated as much by youths and their parents as by senior athletes and, therefore, they result more frequently in time lost from practice or competition⁶¹. No differences exist in the proportion of fractures and dislocations between age groups, with percentages being consistently low.

Injuries can also be classified into traumatic (acute and chronic) and stress (overuse) injuries, different mechanisms being involved in the aetiology of these injuries^{54, 58, 85}. It has been reported in senior players that approximately two-thirds of the injuries are traumatic in origin and one-third overuse^{20, 55-58}. Following on from this both Ekstrand and Gillquist⁵⁸ and Engstrom et al.⁵⁶ found two-thirds of the traumatic injuries to occur during competitive games with overuse injuries being predominant during pre-season training. Similarly, in a prospective

study on 1018 players from an Italian professional football club, traumatic injuries were more frequent during official games (64% of all injuries) than during training ⁷³.

Location of injury

The majority of football injuries are known to occur in the lower extremity, which when expressed as a percentage represent 65-88% of the total number of injuries. Injuries to the lower extremity in professional footballers have been reported to amount to 72%⁶¹ of the total injuries, 88%⁵⁴ and 78%⁸⁶ for senior amateur players, and 68%⁵³ and 65%⁶⁷ for youth players. This difference between ages reflects the higher incidence of head, face, and upper extremity injuries among youth players^{53, 67, 84}, speculative suggestions for this being more frequent falls on outstretched hands, illegal ball upper extremity contact, or the increased fragility of growing upper extremity epiphyses⁶¹. Not all studies, however, support these findings^{65, 69, 72}.

The knee and the ankle have been reported to be the most common location of football injuries^{11, 53-58, 72, 76, 83, 87}, with a tendency in professional and senior football for a greater percentage of injuries to the hip and thigh^{20, 77, 83, 87}. The incidence of specific types of injuries and their locations do vary somewhat between studies, however strains of the anterior and posterior aspects of the thigh, the adductors and gastrocnemius and sprains of the foot, ankle and knee are common injuries^{19, 53-56, 58, 70, 71, 76, 83}, and contusions of the lower leg have been reported to be the most common injury in youth players^{53, 67, 70, 76, 84}.

Mechanism of injury

Since acute traumatic injuries occur at an identifiable point in time it is possible to identify a player's activity at the time of injury. Overuse injuries occur more insidiously without a specific acute initiating event which results in a greater difficulty in stipulating an injury mechanism. Contact injuries have been reported as being the principal mechanism, Sandelin et al.³³ finding 52% ($P<0.001$) of injuries to occur through physical contact with another player, 29% being non-contact injuries and 5% the result of a direct blow from the ball. Thirty-eight percent of the injuries in a study by Anglietti et al.⁷³ were found to be the result of player-to-player contact, this percentage increasing for goalkeepers (50%) and defenders (40%). As already discussed Ekstrand and Gillquist⁵⁴ reported that two-thirds of the traumatic injuries occurred during games. Of these injuries 59% took place during physical contact with another player, the majority of the non-contact injuries being identified as having occurred during running or cutting (changing direction). The same authors reported 39% of the traumatic game injuries to happen while the player was in possession of the ball⁵⁴.

With regards to the nature of injuries and their mechanisms Ekstrand and Gillquist⁵⁴ found

strains to occur mainly during running and cutting, knee sprains during 'charge-tackling' or 'block-tackling', with sprains to the ankle being the result of most actions. Anglietti et al.⁷³ found most ankle sprains to occur by inversion (70%) and without any contact, while the mechanism for muscular strains was reported to differ depending upon its location; the rectus femoris strains occurred while kicking (86%), and strains to the hamstrings or gastrocnemius while sprinting (91%). In a study on elite footballers in Iceland Arnason et al.⁸⁸ found the majority of strains (84%) to occur during sprinting, shooting or kicking the ball, most sprains (68%) to take place during tackling, while contusions were the consequence of other types of physical contact. This is supported by Anglietti et al.⁷³ whose work reported contact injuries to represent the major source of sprains, particularly for the knee, although in 37% of the cases knee sprains occurred without contact. Concerning player position, Anglietti et al.⁷³ found midfielders and attackers to more frequently sustain an injury while running, falling or kicking compared to other positions, although there was no supportive statistical evidence.

The decision made by the referee with regards to any incident leading to an injury has been considered in a number of studies^{34, 54, 68}. Similar results have been documented, Jorgensen⁶⁸ finding 25% of football injuries to be the result of a foul, Minarovjech³⁴ reporting 15% of the injuries in the first league in Czechoslovakia to be the result of a rule offence, while Ekstrand and Gillquist⁵⁴ found 30% of the traumatic game injuries to be caused by a foul in the referees judgement. Following these figures they reported that 76% of the injuries associated with fouls were caused by the opponent, however, they also reported that those individuals who committed the fouls sustained more serious injuries than those players who were fouled ($P < 0.01$)⁵⁴.

Severity of injury

The length of time lost from practice or play can be used to evaluate the severity of an injury, which as mentioned is the natural progression from using an injury definition based on time absent from sport. However, Inklaar³⁰ suggested that where the duration and nature of treatment are used to assess the severity of injury, the results will possibly be biased by the level of play and sociocultural background, with differences in access to and availability of medical care and rehabilitation being present, quality medical care and rehabilitation possibly decreasing or increasing the sporting time lost. Despite this though, sporting time lost does give the most precise indication of the consequences of an injury to an individual⁵⁹, many studies thus classifying the severity of injuries on this criteria.

Different classification systems have been cited in the literature, several authors^{19, 20, 67} having a system similar to that used by NAIRS⁶² where minor injuries are those resulting in an absence from participation for 1 to 7 days, moderately serious injuries being 8 to 21 days, and serious

injuries resulting in over 21 days absence or permanent damage. Other authors^{33, 54-56, 58} have used a slightly different classification system, still utilising a system involving three levels of severity, however moderate injuries are those where the player is absent from participation from one week to one month, and subsequently major injuries result in a absence of greater than one month. The results of several studies are shown in Table 1.1.

Table 1.1: Injury severity by percentage of total injuries defined by time lost.

<i>Reference</i>	<i>1-7 days</i>	<i>8-21 days</i>	<i>>21 days</i>	<i>Total injuries</i>
McMaster and Walter ¹⁹	76	12	12	60
Sullivan et al. ⁶⁷	50	47	3	34
Albert ²⁰	72	24	4	142
	<i>1-7 days</i>	<i>1 week-1 month</i>	<i>>1 month</i>	<i>Total injuries</i>
Ekstrand and Gillquist ⁵⁸	62	27	11	256
Nielsen and Yde ⁵⁵	46	19	35	109
Engstrom et al. ⁵⁶	27	39	34	85

In a 2 year study involving 20 professional players from F. C. Porto the prevalence of muscle injuries and the number of training days and matches missed were recorded⁸⁹. Over the two seasons 100 official matches were played and 85 muscular injuries occurred; a total of 871 days of treatment were required, 706 days training and 113 official matches were missed by injured players, resulting in an average of 10.2 days if treatment, 8.3 days of training and 1.3 matches missed per injury. Hamstring injuries accounted for 43% of the injuries, costing 8.9 days of treatment and 1.7 missed matches for each injury; 19% of the injuries were to the rectus femoris, costing 13.5 days of treatment and 2.4 matches. Training injuries were more severe than those sustained during matches; 12.0 days of treatment were required and 2.1 games were missed compared to 8.9 and 1.1, respectively for the match injuries.

Time of injury

The incidence of injury has been reported to vary not only through the course of matches themselves but also over different periods of the playing season. Ekstrand and Gillquist⁵⁴ found two peaks to occur, one of which followed pre-season and the other the mid-season break, which was supported by the work of Sandelin et al.³³ who also reported two peaks during the season when significantly more injuries occurred ($P<0.001$), these months being August and May. Three peaks were reported by Lewin⁹⁰ from his one season study on an English professional football club. These appeared during the months of September, December and April, being

described as the start of the competitive playing season and two match-intensive periods of Christmas and Easter, respectively. Although the comparison of these results is difficult due to the different seasonal structure present in different countries, Ekstrand and Gillquist^{54, 58, 86} did report an increase in injury rate around periods of intense competitive matches. It is important, therefore, that when such analyses are made the number of games played over the study period are accounted for. Not all studies however have found injury incidence peaks during a playing season. The 11 year prospective study of an Italian A league team⁷³ did report 53% of the injuries to occur in the months of October to November and April to May, i.e. the beginning and end of the championship. However when the professional players were analysed separately away from the junior division and junior professional athletes it was found that their injuries were distributed uniformly throughout the season. It is possible that these players are at an ideal state of physical fitness when their playing season commences making them less vulnerable to injury, their physical condition being adequately maintained throughout the playing season.

With regards to the actual timing of the injuries during games and training Ekstrand and Gillquist⁵⁴ reported 58% of the game injuries to take place during the first half, with strains being most common during the warm-up and start of the game ($P<0.05$), and ankle sprains being evenly distributed throughout. The authors did not report any differences in training concerning strains and ankle sprains, although knee sprains were reported to be most common at the end of sessions ($P<0.05$). Different patterns have been documented by others, Sandelin et al.³³ showing a slight tendency for more injuries to occur in the third quarter of a game, while Arnason et al.⁸⁸ found a greater number of strains to occur during the second half of games and practice sessions ($P<0.02$), with no difference associated with the timing of sprains and contusions.

1.5.2 Aetiology of Injury

The aetiology of sports injuries have been addressed by several authors^{59, 85, 91-99}, with injuries normally found to be the result of a summation of several factors. It is, therefore, clearly difficult to establish a cause and effect relationship. Risk factors include the sport itself, the level of competition, equipment used, coaching techniques employed, and playing conditions, all of which interact with physical characteristics and personality traits. These can be classified into one of two categories^{85, 100, 101}: intrinsic (personal) factors and extrinsic (environmental) factors. There have been many epidemiological studies on sports injuries which have focused on one type of injury, one type of sport or one specific risk factor, with several authors identifying key factors involved in the pathogenesis of sports injuries^{54, 58, 102, 103}. However, although many potential risk factors have been identified there still remains limited epidemiological research to support them, a lot being based on common sense or faith. It has also been suggested that an

unpredictable element will always be present⁹⁸.

1.5.2.1 Intrinsic factors

Flexibility

Deficits in flexibility have long been believed to be a risk factor in athletic injuries. In sports in general it has been suggested that stiffness of the lower extremity muscles, leading to a decrease in the range of motion (ROM) of surrounding joints, is a musculoskeletal injury aetiological factor¹⁰⁴⁻¹⁰⁸. It has been suggested that if ROM is restricted by muscular tightness then this possibly predisposes the muscle to rupture and tendinitis¹⁰⁹⁻¹¹² and possible performance decrement. In elite football players joint flexibility, being a combination of active joint mobility, ligamentous laxity and muscle tightness, was identified as a risk factor of injuries¹¹³. In amateur Swedish football Ekstrand and Gillquist⁸⁶ found that generally the flexibility of players was less than age-matched non-players, muscle tightness being reported in hip abduction, hip extension, knee flexion and ankle dorsiflexion ($P<0.001$), 67% of the players being identified as having one or more tight muscle groups in the lower extremity. From 44 football players who sustained a muscle rupture or tendinitis in the lower extremity, 34 were identified as having muscle tightness ($P<0.05$), and the 13 players with an adductor rupture or tendinitis showed a decrease in ROM in hip abduction compared to the other 167 players in the study, none of whom sustained any adductor injuries ($P<0.05$)⁵⁸. Lysens¹¹³ did report a correlation between muscle tightness and strains of the thigh and adductor muscles, with Schmidt-Olsen et al.⁷² supporting the view that poor flexibility is a risk factor since fewer muscular problems were found in youth football players possibly being the result of greater flexibility.

There is some debate though with not all studies reporting strong correlations between present flexibility measurements and previous muscular strains. Ekstrand and Gillquist⁸⁶ looking at previous injuries found players with tightness did not show a greater incidence of ankle or knee sprains, and although a tendency for a greater number of strains in those with muscle tightness was present no significance was reported. It should be noted that whether muscle tightness is the result or the cause of a strain cannot be determined in a retrospective study and thus these results should be interpreted accordingly.

Causes of poor flexibility are not known. Muscle tightness aetiology has been reported as being abnormal shortening of the muscle due to old injuries with persistent scar tissue, fibrosis, and adhesions in muscles and surrounding structures¹¹⁴. Inklaar³¹ suggests that previous muscular injuries may play a role and that the sporting demands placed upon strength and power are influential along with the definite lack of attention paid to flexibility work during training

sessions. The greater flexibility that was found in the hamstrings compared to the reference group in the study by Ekstrand and Gillquist⁸⁶ was thought to be due to its inclusion in training.

Lack of flexibility has been associated with certain types of injury but no clear evidence exists^{58, 86, 100}, possible reasons include the lack of clear definition of flexibility and the inadequate evaluation of the techniques used. Although it has been reported that 11% of all injuries in footballers are related to muscle tightness⁵⁸, causality has not been proven. There remains a lack of evidence supporting the view that a lack of flexibility predisposes one to injury; conventional wisdom would suggest that shortness of muscle and connective tissue limits joint mobility and consequently may predispose that muscle or connective tissue to injury. It appears then that players would most probably benefit from flexibility programmes, many authors having suggested that stretching and other flexibility exercises lead to injury prevention and improved performance^{109-112, 114, 115}, stretching having been proved to eliminate muscle tightness¹¹⁶, however the evidence supporting the common view that greater ROM decreases the risk of injury remains equivocal.

Muscular strength

It is a popular axiom that strong athletes are better performers and have fewer injuries^{111, 117, 118}. The risk of injury does seem to increase as a consequence of muscle asymmetry regardless of an athletes relative strength, although Ekstrand and Gillquist⁵⁸ only reported a correlation between strength and injuries with regards to non-contact knee injuries. In their prospective study on 180 senior amateur football players it was reported that those players who sustained a knee injury as a consequence of a non-contact mechanism possessed reduced knee extension strength in the injured leg compared to the non-injured leg ($P<0.05$), strength being determined by isokinetic dynamometry. A significantly lower strength quotient of the injured/uninjured leg in the players sustaining non-contact injuries compared to the right/left quotient in uninjured players was also found ($P<0.01$). However, mechanical instability was reported to be present in the majority of players injured during non-contact mechanisms, this being the result of previous injuries. The cause of re-injury was probably therefore due to inadequate rehabilitation, resulting in muscular weakness.

Extension imbalance of the quadriceps has been reported to differ between non-injured and injured sportsmen, an increased imbalance being associated with an increased risk of injury¹¹⁹. Although when analysed as an independent factor no significance was found, when the analysis was applied to lower extremity injuries alone extreme extension imbalance in males was reported to be a significant independent risk factor for injuries to the lower extremity. It is worth noting that this study was based upon the collection of sports injury data retrospectively, the

results then being related to physiological, psychological and physical fitness variables collected 6 years earlier. Poulmedis,⁸³ in research on Greek football players, produced findings suggesting that decreased muscular strength in either the hamstrings or quadriceps predisposed the thigh to muscular injuries, a significant correlation being reported between the hamstring/quadriceps ratio and muscular strains ($P < 0.001$ and $P < 0.05$ for right and left leg, respectively).

The belief that muscle strength imbalance between ipsilateral antagonists or between identical bilateral muscle groups are risk factors associated with lower extremity musculoskeletal injuries is supported by Grace¹²⁰ and Agre¹⁰⁵. However, sound epidemiological studies to support these assumptions are lacking. Lysens et al.¹²¹ showed that men who displayed high functional strength, upper body strength and limb speed appeared to be predisposed to acute injuries. It was suggested that those individuals who possessed great dynamic strength could reach a high kinetic peak load during activity resulting in a greater risk of acute violent insults. This was supported by Ekstrand and Gillquist⁵⁸ who said it was important to make a distinction between fast and slow muscle strength, dynamic strength possibly being a risk factor while static strength provides a stabilising effect and therefore protection. The evidence supporting the belief that athletes possessing muscular strength imbalances are subjected to a greater risk of injury remains equivocal at best, indicating the necessity for more research into identifying the injury prone athlete.

Endurance

Overuse injuries and sprains were reported to be related to maximal oxygen uptake ($\dot{V}O_{2max}$, ml/kg/min) in a prospective study of 40 male senior amateur football players¹²². It was found that there was a significantly higher incidence of overuse injuries among the group of players with a high estimated $\dot{V}O_{2max}$ compared with players of a lower $\dot{V}O_{2max}$ ($P < 0.05$), possible explanations being attributed to the greater training intensity by the high $\dot{V}O_{2max}$ group. Training nature and exposure were not, however, assessed. A tendency for a greater number of sprains in the group possessing the lower $\dot{V}O_{2max}$ values was seen with time to fatigue and decreased muscle strength being proposed as plausible explanations.

In research on animals performed by Safran et al.¹²³, it has been demonstrated that musculoskeletal damage resulted from muscle fatigue and eccentric muscle contraction compared to no muscle damage during muscle fatigue and isometric or concentric contraction. This can be related to the swing phase of running, during which the hamstring muscle group is working eccentrically to decelerate the lower leg resulting in the generation of high forces, which may result in injury if fatigue occurs. This is however speculative, therefore requiring

further research. In this situation the athlete's diet cannot be over emphasised. Briefly, proper ingestion of carbohydrates in either the fluid or solid form is important, especially during pre-season training, to replenish muscle glycogen stores and possibly prevent injuries by diminishing fatigue ¹²⁴. Again this is speculative, but considering the role of muscle fatigue and eccentric contraction has been identified as a factor in injury causation ¹²⁵, it would seem probable that since dietary intervention can delay the onset of fatigue ¹²⁶ it may also be able to prevent certain injuries, such as strains to the hamstring muscle group when players with depleted stores of muscle glycogen attempt to sprint, this being the typical activity during which hamstring strains occur ¹²⁷.

Previous injuries

Inadequate rehabilitation and premature return to activity are injury risk factors, based on the high percentage of re-injuries that take place in football. For example, Ekstrand and Gillquist⁵⁸ attributed 44 injuries to inadequate rehabilitation, and 32 of 97 moderate and major injuries were reported to occur within 2 months of a minor injury, 41% of these being of the same type and location. There were 7 minor injuries within 2 months of other injuries, and 5 of the 18 knee injuries had inadequate rehabilitation with persistent muscle weakness after a previous injury. Similarly, Nielsen and Yde⁵⁵ reported that there was an injury of the same type and location in the preceding year in 42% of the injured players, with 59% of these not having completely recovered from their previous injury. In a study on elite football players in Belgium it was reported that 30% of muscle strains and sprains were re-injuries of the same type and location ¹¹³.

Incomplete rehabilitation seems to be a problem when new ankle and knee injuries are correlated with previous injuries to the same joint. Following ankle and knee sprains a high prevalence of persistent mechanical instability has been reported in senior male amateur players⁸⁶. The use of stabilometry ¹²⁸ and anamnesis ⁵⁵ has found functional instability in players with and without previous ankle sprains. It is believed that both types of instability predispose the ankle and knee to sprains, however, those ankles which have previously been sprained have been found to be more susceptible to sprains than those which have not⁵⁴. If a player had previously sustained an ankle sprain then Ekstrand and Tropp⁷¹ reported that there was a 2.3 times greater risk of sustaining another one. In the study by Nielsen and Yde⁵⁵ 56% of ankle injuries involved players with a previous history of ankle sprains. The injury mechanism seems to be important since it was reported that in 80% of players who sustained an ankle sprain for the first time, the injury mechanism was tackling while those players injured during running all had previous ankle sprains ⁵⁵. Ekstrand and Gillquist⁵⁸ found that the more severe knee sprains which were the result of non-contact mechanisms were more commonly found in players with previous knee

sprains and persistent mechanical instability compared to the contact knee injuries.

It appears that those athletes with a history of injuries are generally at a high risk of recurrence^{101, 102, 121}, injuries with the highest risk of re-injury being sprains of the ankle^{55, 58, 71, 113}, and the knee^{58, 71, 113}, and strains of the thigh and lower leg^{54, 55, 113}. When addressing the problem of re-injuries consideration must be given to poor rehabilitation which probably results in a lack of return of functional stability, muscular strength, flexibility, cardiovascular endurance, co-ordination, skill and confidence when the player returns to competition. The underlying problems seem to be the under-estimation of the severity of the initial injury, inadequate rehabilitation and/or the premature return to sporting activity⁹⁸.

Other factors

Several other factors have been considered as intrinsic aetiological injury risk factors. Somatotypes have been considered as a contributing factor to sports injury incidence, with muscularity supposedly protecting the athlete, and obesity, which is inversely related to fitness, resulting in a risk due to reduced motor and/or endurance abilities⁹⁸. Marti et al.¹²⁹ reported the risk of sustaining an injury in runners to be enhanced if their body mass index (expressed as body weight per body height squared) was greater than 27.

Lysens et al.¹²¹ constructed a profile of those physical characteristics that subject the athlete to overuse injuries. They include lack of static strength and ligamentous laxity in combination with muscle tightness and specific malalignment disorders, excessive body length and weight, and great explosive strength which can disrupt the balance between load and load-carrying capacity. This confirms the hypothesis of several authors that muscle tightness is predisposing to muscle strain or tendon problems^{54, 58, 130}. The problem seems to escalate as a result of muscle weakness¹²¹, it being argued that more muscular individuals have a higher load-carrying capacity and are therefore less susceptible to the risk of overuse injuries since they are more equipped to withstand the stresses of their sport; against this argument however, body weight and length possibly increase the intrinsic load athletes expose themselves to because of the increases in the forces generated internally, thus increasing their susceptibility to injury⁹⁸. Finally, malalignment of lower extremities can cause malfunction and disuse^{101, 131}. For example, excessive or prolonged foot pronation is associated with tibial stress syndromes and pes cavus reduces shock absorption, possibly leading to Achilles tendon problems and plantar fasciitis. There are other anatomical abnormalities which can lead to overuse syndromes, however these are beyond the scope of this work.

There may well be other factors relevant to injury such as skill levels, attitude, personality, and

other psychological factors, however, it has proved to be difficult to quantify these variables, and as research in this area is still in its infancy few associations have been made.

1.5.2.2 Extrinsic factors

Training load

Ekstrand et al.¹⁵ in their prospective study found a non-linear relationship between training and injuries. Those teams which trained less than average showed an increase in the number of injuries with an increase in the number of hours trained, while those teams who trained more than average showed a decrease in the number of injuries with an increase in training ($P < 0.01$). The 6 teams with the higher than average training had fewer traumatic injuries per hour of practice than the 6 other teams who did less than average training ($P < 0.05$). Overuse injuries per hour trained were the same for both groups. The authors attributed this decrease in traumatic injuries to better co-ordination and oxygen uptake, greater strength and more skill, although there was no evidence to substantiate this. It seems then that a high practice-game ratio is beneficial for reducing the incidence of traumatic injuries. A positive correlation was also found between team success and the amount of training ($P < 0.05$), although the individual leagues in which the teams play need to be considered. Ekstrand and Gillquist⁸⁶ stated that the disposition of football training plays a large part in the injuries discussed, suggesting that many could be avoided if there was a modification in training methods.

Warm-up and cool-down

A warm-up prepares the body for a workout or competition by raising muscle temperature towards an optimum level for performance¹³², enabling metabolic processes in cells to proceed at higher rates¹³³ and nerve messages to travel faster¹³⁴, physical performance having been shown to improve following a warm-up¹³². Also, a warm-up will reduce the viscosity of the exercised muscles, relaxing them, and when combined with stretching the elasticity of muscles is further increased thus increasing the force requirement and degree of lengthening needed to tear a muscle¹²³. Two types exist: a specific warm-up includes movements that either mimic or are employed in the actual sporting activity; a general warm-up may consist of various types of movements which are not directly related to those employed in the sport itself e.g. for association football this may include callisthenics, jogging and cycling. Warm-ups should be intense enough to increase the body temperature, the effects of which will ultimately wear off depending upon its intensity and specificity¹³³. Warm-up exercises should be specific to the muscle groups that are to be used in the main activity and also those which are subject to greater risk. Kurz¹³⁵ described the aims of a warm-up as being to increase awareness, improve co-ordination, improve elasticity and contractibility of muscles, and increase the efficiency of the

respiratory and cardiovascular systems. A cool-down helps the body to recover from a workout or competition, the removal of by-products being assisted by movement which increases blood flow, preventing the pooling of blood¹³⁶. Stretching is an important part of the process but alone it is not a legitimate way to cool-down.

In sports generally a lack or improper use of a warm-up and a cool-down has been proposed to be a risk factor for lower extremity overuse musculoskeletal injuries^{104, 107}, especially during running⁶⁴. Reilly and Smith¹³⁷ have shown that neuromuscular and cognitive performance are improved by concomitant exercise up to 40-50% $\dot{V}O_{2max}$, reflecting a warm-up effect.

Stretching is important before exercise because the ability of the musculotendinous unit to absorb energy is directly related to the muscle temperature and muscle length^{123, 138}. ROM exercise techniques should be designed to primarily produce plastic deformation, i.e. the deformation produced by tensile stress remains after the stress is removed. This needs to be accomplished without the connective tissue being physically torn. The mechanical behaviour of connective tissue under tensile strength is significantly influenced by temperature, tissue stiffness decreasing and extensibility increasing with increases in tissue temperature¹³⁹. It is because of the high tissue temperatures achieved after the main activity that it is advised that stretching activities be incorporated into the cool-down period. Sapega et al.¹³⁹ have reported that the amount of elongation that remains following the removal of tensile stress from connective tissue being stretched at an elevated temperature is influenced by the way it is allowed to cool; maintaining tensile force during tissue cooling is suggested to increase the relative proportion of plastic deformation compared to releasing the tensile force while the tissue temperature remains elevated.

The education of athletes is of a critical importance, the benefits and contraindications being identified. For example, attention should be brought to the issue that certain stretches can lead to injury, such as the hurdler-stretch putting stress on the medial collateral ligament and medial meniscus¹⁴⁰. A warm-up is important, both physiologically and psychologically, however there is a large amount of inconclusive evidence that it reduces injuries, with a general lack of epidemiological evidence to support the preventive effects of warm-ups, cool-downs, and stretching on running injuries, data being difficult to obtain.

Equipment

Shin-pads are the only piece of protective equipment routinely worn by footballers. Their use now during competition is compulsory but their use during training remains optional. Ekstrand and Gillquist⁵⁸ reported that only 30% of the senior players they questioned wore shin-pads

during training. Four percent of the injuries were found to be traumatic in nature and to the lower leg, resulting in an average of 3 weeks absence, the injured players having been assessed as either wearing inadequate shin-pads or none at all; how this was determined though is unclear. Backous et al.⁷⁰ reported that the proportion of leg injuries increases by the failure to wear shin-pads. It was found that only 2.2% of youth players who wore shin-pads sustained an injury to the leg compared with 10.5% of the players who did not wear shin-pads. It has been suggested that shin-pads are insufficient in size and therefore protect too small an area, and also that they possess inadequate shock absorbing qualities⁵⁸; however, this was in 1983 and since then changes have been made. There still remains a limited amount of research on shin-pads and their protective value so more research in this area is clearly needed.

The modern football shoe is believed to have very little support and no cushioning¹⁴¹. The author found several problems with the feet and ankles of players from the US men's senior National and Olympic football teams due to the stresses that their feet are subjected to. Ekstrand and Gillquist⁵⁸ attributed 13.3% of reported injuries to poor footwear, two-thirds of which were overuse and usually the result of the poor shock absorption qualities of the shoe in relation to the playing surfaces or even due to the frequent nature of changing the type of surface on which they played during the winter. They also reported that knee sprains may have been caused by the twisting of the knee while the foot was fixed in the ground, attributed to the screw-in-studs, although there were no statistics reported on the number and length of studs. Since there are changes in the forces and moments acting on the body as the surface and shoe are changed¹⁴², the frequency and type of injuries depend to some extent upon the player, the surface and the shoe. The playing surface needs to be considered together with the surface-shoe interface. Ekstrand and Nigg⁹⁵ have suggested that there is an optimal range in which the frictional resistance between the shoe and surface must lie due to the nature of the game, which involves movements such as sprinting, stopping, cutting, and pivoting.

The stiffness of the playing surface is believed to be an influential factor with regard to the frequency of injuries. Overload injuries of bone, cartilage, ligament and tendon can be caused by impact forces, whether from one excessive impact or several submaximal forces; the critical limit varying with subject and tissue. Friction is important with regard to acute traumatic injuries. Consideration of translational and rotational friction is therefore required; the latter depends on the size of the contact area and the pressure upon it, while the former depends upon the shoe-surface material. Ankle and knee ligament injuries often result from players being tackled while the weight bearing leg is fixed to the ground, resulting in high translational and/or rotational forces. Ekstrand and Nigg⁹⁵ have suggested that it is the height of the studs that may influence the injury risk since they will increase the distance from the ground to the subtalar

joint and therefore there will be a greater moment to the subtalar axis. A compromise is therefore required as translational friction forces are required to enable the player to stop and start and make changes in motion while rotational forces need to be reduced for the purpose of decreasing the incidence of injury.

Physical factors could be a risk as several authors have reported that a quarter of injuries are contributed to by poor field conditions^{58, 67}. Hard, slippery, uneven surfaces, and inadequate safety margins around the playing perimeter have been investigated^{15, 19, 34, 58, 67, 143} with results indicating a higher incidence of injuries during winter and pre-season training^{15, 56, 57} when playing surfaces are renowned for being hard. Astro and turf-grass have been reported to produce differences in injury mechanisms and patterns²⁰ with the shoe type being suggested as the most probable compounding factor³¹. The argument over whether playing on artificial pitches instead of grass leads to more injuries is continually being debated, however interest in football injuries became less acute after artificial surfaces - put in by Luton Town, Preston North End and Queens Park Rangers - were banned by the Football League in the late 1980's. The problem though still remains at the lower levels of the game and also in other sports such as hockey, this being highlighted in the early 1990's when several leading hockey internationals suffered severe back injuries¹⁴⁴. Consideration should be given to other factors though, such as elite hockey being exclusively played on artificial surfaces, the demands of the game requiring players to spend a lot of time with the trunk in a flexed position, and the speed of game being much faster than that previously seen on grass. Although it has been suggested that there is a greater injury risk inherent in playing on synthetic surfaces than on grass¹⁴⁵, there remains an absence of any scientific work with most of the evidence being anecdotal. Frequent alteration in playing surface has also been previously blamed as a contributory injury factor^{35, 146}.

Other factors

Other extrinsic aetiological factors associated with injuries include climatological conditions with several authors proposing that it is its influence on the playing surface that is the critical factor^{34, 35, 58}. Sports related factors include the role of opponents and team mates, and the way in which referees enforce the rules of the game. These have been discussed earlier under the mechanisms of injury, however, it has been suggested that coaches and referees should enforce safe and more sportsmanlike play⁶¹. As previously discussed, it is not possible to attribute one or more of the above risk factors with every injury; in work on Swedish football injuries 72 from a total 256 injuries were considered as being the consequence of a chance event⁵⁸.

1.6 Aims of the Study

By applying a risk management approach the risk of injuries in professional football should be reduced. The risk management process aims to identify the likely factors that lead to injury, measuring the severity of those factors to cause injury, followed by the implementation of control measures to reduce the risk or eliminate the hazard completely. The current literature fails to identify the hazards to which professional footballers are exposed to during their employment. Consequently, no risk assessment has been undertaken to evaluate the likelihood that harm will occur and the severity of any resulting injury. The current research aims to address these issues in English professional football, providing a foundation for the introduction of potential injury preventative measures, forming part of a risk minimisation process.

Chapter 2 involves the first step of the overall risk assessment process by assessing the risks to professional footballers' health and safety at different levels of competition, examining the accidents and incidents aiming to identify the most common causes of injury. There are anticipated drawbacks of this method of evaluation since although it is believed that the analysis of matches will itself provide an indication of the potential for injury in professional football, in depth epidemiological data will not be made available.

The extent of the sports injury problem requires preventive action to be implemented based on the results of epidemiological research. Because of individual sport cultures and different sport habits in different countries, national epidemiological studies are required in each individual country. Chapter 3 documents the injury epidemiology from several English professional football clubs, spanning a period of 2-3 competitive seasons. The aim is to provide an insight into the aetiology of professional football injuries in England, identifying those areas requiring some form of preventive action or further study. Comparisons between the club injury data and the match analysis can be made, especially where matches analysed involve clubs at which their physiotherapists provide injury reports.

There is a legal requirement for employers to provide adequate information and training to their employees with regards to their health and safety and the hazards and risks they are exposed to. Within football, the aim is to ensure that current playing and coaching practices incorporate current knowledge, and provide information for the protection of all professional players and apprentices. Chapters 4 and 5 focus on this area: the prevention of injuries is made complex as a result of the accumulation of aetiological factors related to football injuries, these factors having been identified as being intrinsic or extrinsic. Chapter 4 involves a study of several extrinsic variables at three English professional football clubs by examining their training practices.

Chapter 5 aims to identify the knowledge professional footballers have, with regards to their awareness and application of strategies for the prevention of injury. It is probable that different injury patterns are observed in different clubs, possibly as a result of the varying practices that clubs employ based on their individual beliefs; comparisons of the results documented in Chapters 2-5 will allow this aspect to be considered, aiming to identify the weaknesses and benefits of certain training principles and practices.

Figure 1.2 illustrates schematically the holistic approach to risk management in professional football adopted in this research. This Figure shows the interdependence of each aspect of the research undertaken and the contribution each makes to the final risk assessment.

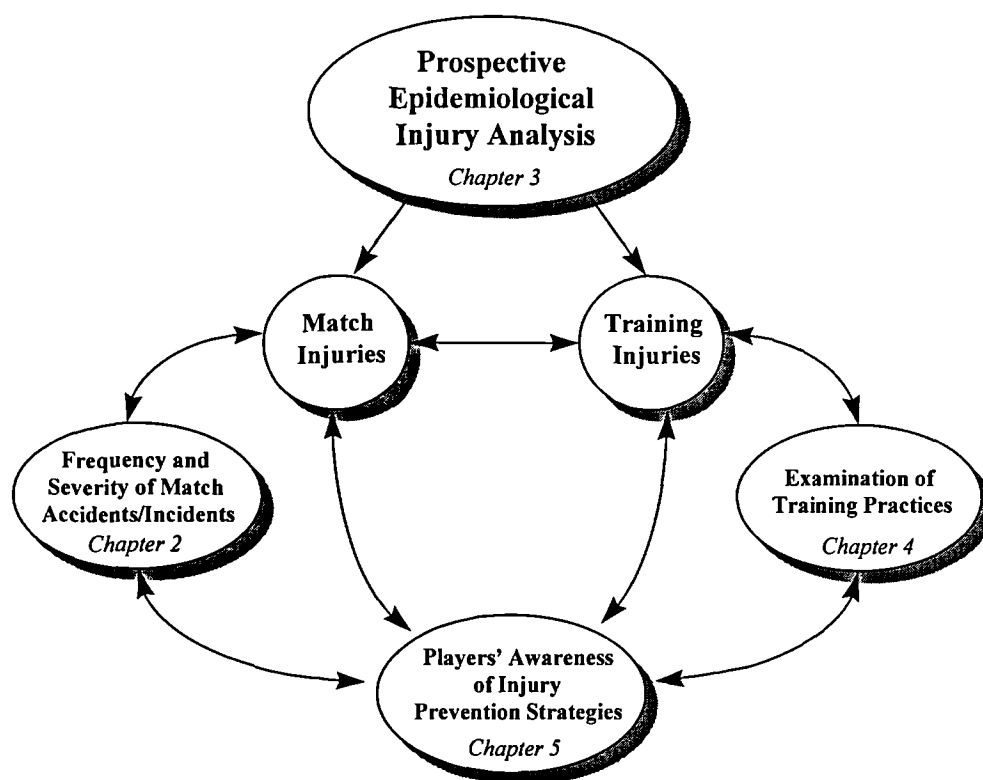


Figure 1.2: Holistic view of the risk management approaches conducted.

The safety of sports is a critical issue and any injuries sustained while either competing or training can prevent many sportspersons, at the recreational as well as the professional level, from further satisfying and healthy experiences. The final two chapters bring together the completed research, discussing the way forward with regards to the prevention of injuries in professional football. Significant changes in the safety of professional football need to be made, with a necessity of increasing the awareness of the cost and debilitating effect of injuries and the continual threat of expensive legal law suits. The risks for injury are identified and the process of developing an injury prevention programme in professional football is discussed.

It is known that 50 to 55 professional footballers have to retire from their profession each year because of injury, an attrition rate of approximately 2% ¹⁴⁷. In summarising, it is the aim of the current research to identify ways by which this rate can be reduced while also lowering the overall injury prevalence currently seen in English professional football, ultimately prolonging players' careers leading to a maintenance of a high quality of life in later years.

CHAPTER 2

AN EXAMINATION OF THE FREQUENCY AND SEVERITY OF ACCIDENTS AND INCIDENTS IN PROFESSIONAL FOOTBALL DURING COMPETITIVE MATCHES

2.1 Introduction

The ultimate aim of health and safety management is the elimination of accidents and ill health: in the case of professional football this would be equivalent to keeping all players fit, at all times, thereby allowing the club management to select from an injury free squad. The benefits of such a situation accrue to both individual players, by possibly enhancing and prolonging their playing careers, and to the football clubs themselves, by maximising the return on their investment. One step towards achieving this aim would be to undertake an assessment of the risks to players' health and safety²³. In the UK, such an assessment is a general requirement of the HASAW Act²⁵ and a specific requirement of the MHSW Regulations²⁶. In risk assessment the emphasis is on preventing accidents by identifying potential hazards (cause of injury), and determining the likelihood (frequency of injury) and consequences (extent of injury) of accidents arising from the hazards. Inadequacies in risk management, highlighted by the assessment, then help to determine the additional control measures that need to be implemented.

One of the underlying principles of successful health and safety management is loss control²⁸. The adoption of a total loss control approach seeks to identify and eliminate all incidents irrespective of whether or not they result in injury. The severity of the outcome of an incident often depends on chance if hazards are not properly identified and the associated risks not controlled. Therefore, since the outcome of an incident cannot be accurately predicted, the only reasonable way in which to reduce injuries is to control all of the underlying causes. The use of accident triangles in loss control theory, shows the relationship between major injuries, minor injuries, and non-injury incidents¹⁴⁸.

Incidents are seldom inevitable random events, and even though the immediate causes of injuries in professional football may differ, such as an unfair tackle or a shot on goal, the underlying cause may be similar. Injuries are usually the consequences of multiple causes, and it is the

intrinsic and extrinsic factors alike, whether they be training aspects, management tactics, or individual attributes and attitudes, that need to be identified and controlled. The causal pathways are complex and the identification and examination of one possible risk factor can only partly begin to address the question of injury prevention. Accurate information concerning injuries is required together with physical and physiological knowledge of the individual players to enable positive steps to be taken regarding injury prevention.

Several methods have been used to objectively analyse matches since there is only a limited amount of information that can be derived from subjective evaluations. Researchers have utilised expensive electronic equipment and video cameras ¹⁴⁹ or developed less elaborate systems of analysis ¹⁵⁰ to obtain objective and systematic recordings of time and motion analysis of teams and individual players. The majority of match analysis techniques have aimed to acquire data on the technical or tactical aspects of football, or have been used to develop activity profiles to assist in establishing the physiological demands placed on individuals; this type of analysis, more correctly termed event analysis in this situation, has not previously been used to establish the frequency of incidents and accidents in professional football.

The demands of football suggest that injuries may be prevalent; e.g. considering that outfield players cover between 9-13 km per game ¹⁵¹ composed of discrete bouts of action incorporating rapid changes in pace and direction approximately every 5-6 seconds ¹⁵². During the typical 90 minutes of high intensity, non-continuous intermittent activity associated with a football match, players are involved in an average of 19 tackles and 13 headings, this number increasing with higher levels of competition ¹⁵³. Taking this into account and the competitive nature in which the game is played, it is not unreasonable to suspect that players sustain both traumatic and overuse injuries. In professional football, research has previously identified that the majority of injuries occur during competitive games ^{33, 40}. Therefore it is essential as part of the overall risk assessment process to gain a closer insight into the types, causes and frequencies of injuries to professional footballers during competitive games.

2.2 Methodology

2.2.1 Data Collection

Over the study period there have been two major international football tournaments and many televised English Premiership and Division One matches. Both the 1994 World Cup Finals,

staged in the USA, and the 1996 European Championship Finals, staged in England, provided a 4 week period of intense football activity, which gave the opportunity of analysing injuries arising from the highest level of international football. During the World Cup competition a total of 52 matches were played from which 44 televised matches were recorded on video-tape for analysis, whereas the European Championship involved 31 matches, 29 of them being recorded and subsequently analysed. From the domestic football, Division One matches were analysed from August 1994 through to May 1997 (26, 29 and 40 matches for the three seasons, respectively), and 49 English Premiership matches were recorded and analysed from the 1996/1997 playing season.

For each match the following incidents were recorded: situations in which a free-kick occurred arising from player contact and situations in which a player received treatment.

The following parameters were identified where appropriate for each incident:

- a. the playing time elapsed in minutes as shown on the video recorder;
- b. whether the treatment was a result of a foul (as indicated by the referee);
- c. whether the foul was judged (by the referee) to be against or for the treated player; and
- d. whether no foul was judged (by the referee) to have occurred even though a player was injured.

For each treatment additional information was recorded:

- a. the identity of the player(s) involved;
- b. his playing position;
- c. the injury mechanism; and
- d. future involvement in the game (e.g. was he taken off immediately, taken off later, or completed the remainder of the game).

Analyses of both the video recording and newspaper reports confirmed the identity of players involved in all analysed games, times of substitutions and the players cautioned or sent off. Any additional relevant information from match commentaries and newspaper reports was also recorded. For the two tournaments the wide and extensive media coverage enabled complete team profiles to be constructed, and allowed reasons for game to game team changes to be identified (e.g. suspension, injury).

Using the above criteria ensured that no subjective assessments of incidents, injuries or

treatments were involved in the methodology. Any uncertainties in player involvement, injuries or any other parameters could be readily resolved by reassessment of the video using slow motion replay if required. Where injury causation could not be identified the injury was recorded but was excluded from specific statistical tests where causation was required to be known.

A standard match analysis sheet was employed for recording all data from each match recorded; an example of this is shown in Appendix 1. The results shown indicate that there were: 15 free-kicks, 7 in the first half and 8 in the second half; 3 treatments, 2 in the first half and 1 in the second, 1 being the result of a foul; 2 of the 3 treatments involved player to player contact, their mechanisms being indicated; the goalkeeper who was treated was removed from play immediately (OI), the defender played on (PO) and the forward was removed later (OL); and the report form indicates that further notes were taken on one of the treatments (*).

2.2.2 Accident/Incident Assessment

Accident ratio triangles

The ratios between accidents and incidents of varying levels of severity can be represented as accident triangles. For general accident analysis, the HSE ¹⁴⁸ identifies several categories and defines them as: fatalities, major injuries, over 3-day injury accidents, minor injuries (e.g. first aid only), and non-injury accidents or incidents. The work of Ekstrand and Gillquist ⁵⁴ could be represented in this way, with four categories being identified: major (absence from practice for more than one month); moderate (absence from practice for more than one week but less than one month); minor (absence from practice for less than one week); and non-injury incidents (see below). Three levels of accident and incident were defined and used to represent the data from the two international tournaments. For the domestic match analysis it was not possible to distinguish between moderate and minor injuries since the data that was available concerning any injury was not as well documented and could not be followed to the extent as those occurring in the tournaments could, therefore, only two levels of accident and incident were used, moderate and minor injury categories being combined. The accident and incident categories were:

- 'moderate' injury: players received treatment on the field of play, or were otherwise identified as having been injured, and subsequently missed at least the following game.
- 'minor' injury: players received treatment on the field of play, or were otherwise identified as having been injured, but were involved in the following game.

- 'non-injury' incident: fouls (referee's judgement) not resulting in injury or treatment.

'free-kicks': relates solely to fouls arising from player contact (excludes off-side, dissent etc.).

The ratios between accidents of varying levels of severity were represented as accident triangles.

Injury frequency rates (IFR)

Accident frequency rates can be compared with accident statistics published by external sources, such as the HSE ⁷. They are usually calculated per 100,000 hours worked. The formula used for calculating accident frequency rate (AFR) is:

$$\frac{\text{number of injuries in period}}{\text{total hours worked during period}} * 100,000 \quad - 2.1$$

In exactly the same way IFR's in professional football can be calculated per 100,000 hours played and be compared with industrial figures. It should be acknowledged that although this calculation will not be a true reflection of the risk of injury to the professional footballer during his working life, since only a small proportion of it is spent during competitive match play the majority being spent during training, it will give an indication of the injury risk during this aspect of their employment.

2.2.3 Statistical Analysis

Data were analysed using the Statistical Package for Social Scientists (SPSS Inc., Chicago, Illinois). In performing statistical analyses Student's t-test for correlated means was used to examine differences between halves at each level of football for the following dependant variables: number of free-kicks awarded; treatments that were the result of a foul; treatments that were not the result of a foul; and the total number of treatments. Student's t-test for correlated means was also used to examine differences at each level of football between the number of treatments that were the result of a foul and the number that were not the result of a foul during match quarters, halves and whole matches. A one-way analysis of variance (ANOVA) for correlated means was used to investigate differences between quarters for each of the dependant variables referred to above, applying a Tukey post-hoc test to identify where differences occurred. A two-way ANOVA with repeated measures on one factor (level of football) was used to identify any differences between the 1994 World Cup Finals and the 1996 European Championships, group matches and knockout matches for each tournament, Division One matches over different seasons, Division One and Premiership matches, and domestic and

international matches for each of the dependent variables referred to above, the Scheffe S post-hoc test being used to identify where differences occurred. The chi-square significance test was used to investigate differences between the number of treatments for players of different playing positions. Statistical significance was accepted at the $P < 0.05$ level. Values are reported as mean ($\pm$ SD).

2.3 Results

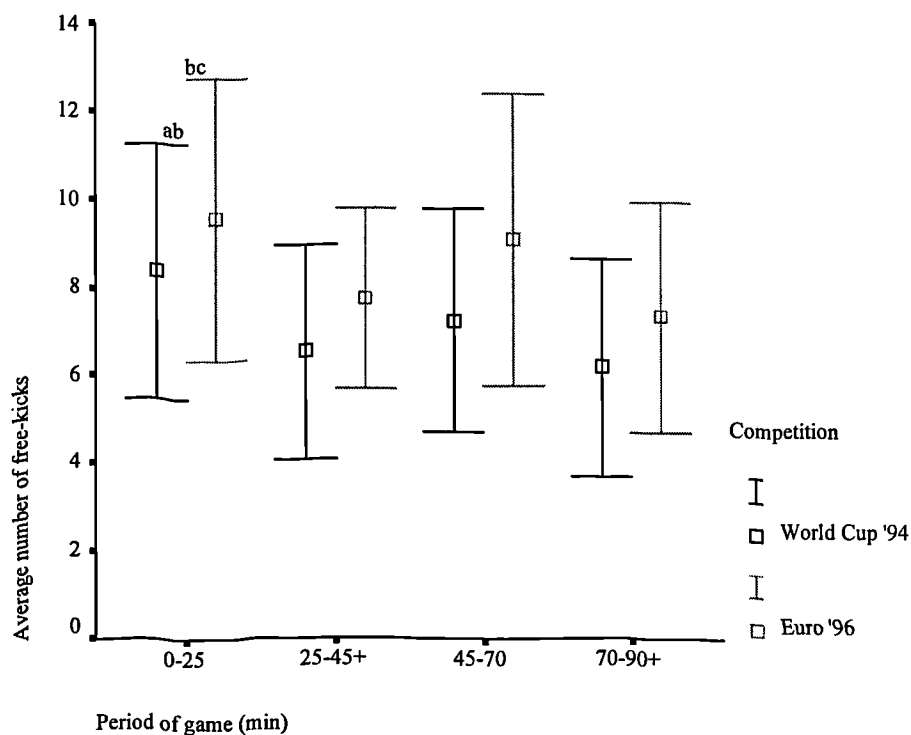
The results are divided into two sections; international football and domestic football.

2.3.1 1994 World Cup Finals and the 1996 European Championship Finals

The 44 World Cup matches analysed, 4 of which included extra-time, represented 85% of the total playing time during the competition, while 5 of the 29 European Championship matches analysed included extra-time resulting in a total of 94% of the playing time being represented. Prior to the commencement of both tournaments all referees were briefed on the required standards by FIFA: hence the level of refereeing over the two periods would be expected to be reasonably consistent. During the 44 World Cup games analysed, 1272 fouls were committed in the referees' judgement in comparison to 1011 fouls committed during the 29 games analysed in the European Championship. These resulted in an average of 28.9 (± 5.4) and 34.9 (± 7.3) free-kicks per game for the two tournaments, respectively ($P < 0.01$). In the World Cup there was a total of 94 treatments, made up of 33 (35%) as the result of a foul, one incident resulting in two players being treated, and a greater number where no foul had been committed (61 (65%), $P < 0.01$), incidents resulting in the treatment of two players each in two cases. Of the 33 treatments associated with free-kicks 10% were administered to the perpetrator himself, and 90% to the victim. There was a total of 70 treatments during the European Championship, made up of 21 (30%) as the result of a foul, one incident resulting in two players being treated, compared to a greater number of 49 (70%) where no foul had been committed ($P < 0.05$), incidents resulting in the treatment of two players each in one case. Of the 21 treatments associated with free-kicks 19% were administered to the perpetrator himself, and 81% to the victim. In addition to the 164 treatments described above there were 30 other instances (20 during the World Cup and 10 during the European Championship), throughout the analysed games, where players were judged to be injured but received no treatment during the course of the game. Of these injuries all but one (which was during the European tournament) could not be associated with a foul and as the timing and mechanisms of these injuries were not known they could not be used in several of the analyses carried out.

2.3.1.1 Fouls and injuries

Matches during the competitions typically consisted, with injury time, of two periods of 50 minutes (min) play. For the purposes of analysis, this playing time was split into 4 periods of approximately equivalent times (i.e. 0 to 25 min, 25 min to half time, start of the 2nd half (45 min match time) to 70 min and 70 min to full time). Figure 2.1 shows the average number of free-kicks awarded for each match in each time period for each tournament and Table 2.1 shows the average number of player treatments in each period for both tournaments. Free-kicks and treatments occurring during the extra-time periods in the nine matches were not included in these figures. During the World Cup a greater number of free-kicks ($30 \pm 10\%$) occurred in the first 25 minutes (0-25 min vs 25-45+ min and 70-90+ min, $P < 0.01$), although there was no difference between the two halves ($53 \pm 15\%$ vs $47 \pm 14\%$, NS). A greater number of free-kicks ($28 \pm 10\%$) during the European Championship also occurred in the first 25 minutes (0-25 min vs 25-45+ min and 70-90+ min, $P < 0.05$ and $P < 0.01$, respectively), although again there was no difference between the two halves ($51 \pm 12\%$ vs $49 \pm 15\%$, NS). The World Cup produced a greater number of treatments that were not the result of a foul in the second half compared to the first ($37 \pm 50\%$ vs $63 \pm 70\%$, $P < 0.05$), contributing to a greater number of total treatments in the second half ($38 \pm 37\%$ vs $62 \pm 54\%$, $P < 0.05$), with 35 ($\pm 14\%$) occurring in the first 25 minutes after half time. There were a greater number of treatments which did not result from a foul compared to those that did over several periods of the game in both tournaments (World Cup: 70-90+ min, $P < 0.05$; and 2nd half, $P < 0.05$; European Championship: 0-25 min, $P < 0.01$; 70-90+ min, $P < 0.05$ and 1st half, $P < 0.01$). Differences between the two tournaments occurred in the first half of matches only with both the total number of treatments and treatments which were not the result of actions deemed to contravene the laws of the game being greater during the European Championship than the World Cup (1.21 ± 1.11 vs 0.78 ± 0.74 and 0.93 ± 1.07 vs 0.49 ± 0.66 , respectively, $P < 0.05$). When results from the group matches operating on a league basis were compared against the matches operating on a knockout basis for each tournament and collectively, no statistically significant differences were observed in any of the parameters analysed.



^a $P < 0.01$ 0-25 min vs 25-45+ min

^b $P < 0.01$ 0-25 min vs 70-90+ min

^c $P < 0.05$ 0-25 min vs 25-45+ min

Figure 2.1: Number of 'free-kicks' during the 1994 World Cup Finals and the 1996 European Championship Finals in each quarter of the game (mean $\pm$ SD).

Table 2.1: Average number of treatments in each quarter of the game during the 1994 World Cup Finals and the 1996 European Championship Finals with respect to refereeing decision.

Time (min)	0-25		25-45+		45-70		70-90+	
	WC'94	Euro '96	WC'94	Euro '96	WC'94	Euro '96	WC'94	Euro '96
Free-kick	0.11	0.03 ^a	0.18	0.24	0.29	0.31	0.11 ^b	0.10 ^b
No free-kick	0.29	0.41	0.20	0.52	0.42	0.24	0.42	0.41
Total	0.40	0.44	0.38	0.76	0.71	0.55	0.53	0.52

^a $P < 0.01$ Free-kick treatments vs No free-kick treatments

^b $P < 0.05$ Free-kick treatments vs No free-kick treatments

Based on the typical 1:4:4:2 (goalkeeper, defenders, midfielders, forwards) playing system used by teams in the competitions, a difference was found between the incidence of injury and number of players for defenders and midfielders during the World Cup, (43% (observed) vs 36% (expected) and 26% (observed) vs 36% (expected), respectively, $P < 0.05$). No statistically significant differences were found for the European Championship results. The ratio of injuries arising from fouls compared to other causes showed no statistically significant differences between playing positions in either tournament.

The kick-off times for matches had no significant influence on the incidence of injuries, the number being evenly distributed across mid-day, afternoon, and evening games.

2.3.1.2 Accident ratio triangles

The approach used by Bird ¹⁵⁴ and Heinrich ¹⁵⁵ to analyse the underlying causes of injuries was used. The technique involves determining the ratios of major, moderate, minor and non-injury incidents occurring in the area of work being analysed. From this data it is then possible to construct accident triangles and compare the results with other activities. A typical accident ratio triangle is shown in Figure 2.2 ²⁸.

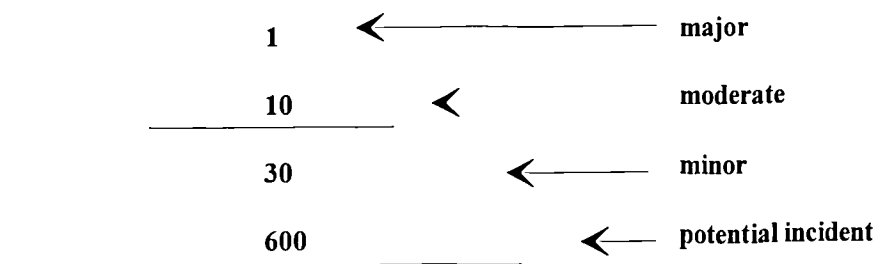


Figure 2.2: A typical four category accident ratio triangle.

All 'injuries'

There were a total of 17 moderate injuries, 97 minor injuries, and 1239 'no injury incidents' (fouls) recorded during the World Cup competition. The equivalent numbers for the European Championship were 12, 68, and 989, respectively. Therefore, for every moderate injury that prevented participation for a minimum of one game there were 6 minor injuries and 73 incidents which could potentially have led to an injury during the World Cup, and 6 minor injuries and 82 potential injury incidents during the European Championship (Figure 2.3).

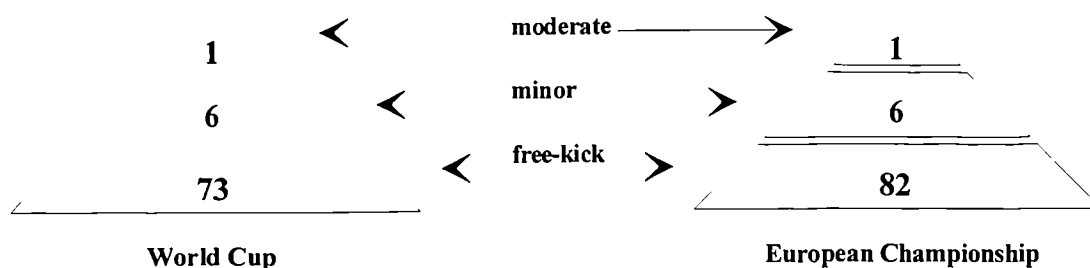


Figure 2.3: Accident ratios for all injuries with respect to potential incidents during the 1994 World Cup Finals and the 1996 European Championship Finals.

These results can be sub-divided into two categories: those injuries resulting from fouls and those where no foul was committed.

'Injuries' resulting from fouls

From the 1272 fouls recorded during the World Cup, 3 incidents resulted in moderate injuries with a further 30 classified as minor injuries. These results included one case where a player sustained a fractured skull in his countries' final game and as this would have definitely caused him to miss any subsequent games the injury was categorised as moderate. There was only 1 incident which resulted in a moderate injury with a further 21 minor injuries occurring from the 1011 fouls recorded during the European Championship. During both tournaments three players, supplementary to the incidents above, were treated in their countries' final games, one of whom was substituted. It was assumed however in the absence of other information that they would have been fit if any further games had been played, and so these injuries were classed as minor. This produced accident ratios of 1:10:413 and 1:21:989 for the World Cup and European Championship, respectively, as shown in Figure 2.4.

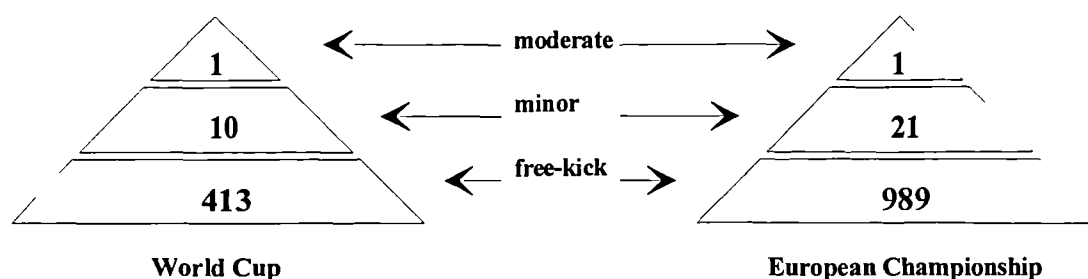


Figure 2.4: Accident ratios for injuries resulting from fouls with respect to potential incidents during the 1994 World Cup Finals and the 1996 European Championship Finals.

'Injuries' not resulting from fouls

During the World Cup there were 14 injuries judged to be at least moderate. Seven of the 14 received treatment during the game, the remainder did not. There were a further 67 minor injuries; 54 receiving treatment during the game. Twelve of the injuries occurred in a country's final game, with 2 of the players being substituted. In the 13 where they did not receive treatment, 7 were substituted in their team's final game. Eleven injuries were judged to be at least moderate during the European Championship. Eight of the 11 received treatment during the game, the remainder did not. There were a further 47 minor injuries; 41 receiving treatment during the game. Fifteen of the injuries occurred in a country's final game, with 4 of the players being substituted, 3 of which were removed from the field of play immediately. In the 6 where they did not receive treatment, none were substituted in their team's final game. By normalising the results on the injuries resulting from fouls in the respective tournament, ratios of 5:22 and 11:47 moderate to minor injuries during the World Cup and European Championship were produced, respectively (Figure 2.5). Possible underlying causes of these injuries are discussed later.

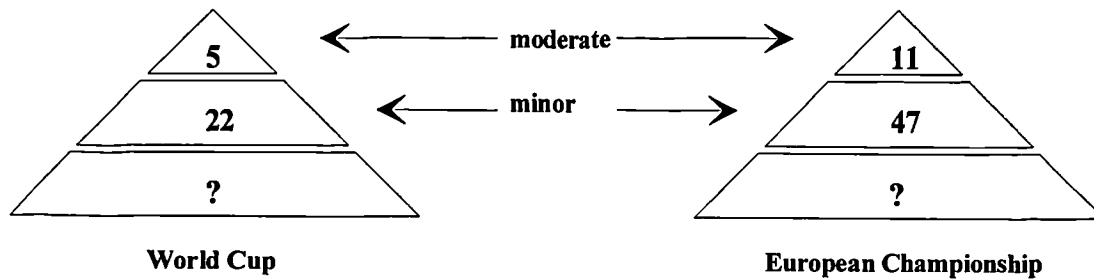


Figure 2.5: Accident ratios for injuries where no fouls were committed during the 1994 World Cup Finals and the 1996 European Championship Finals.

2.3.1.3 Injury incidence rates

If the 24 teams represented in the World Cup utilised all twenty-two players in their squads then 528 players would have been involved in the 52 matches. Based on the same principle for the 16 teams involved in the European Championship 352 players would have been used in the 31 matches played. However only 2 countries used all their players during the World Cup while none did during the European Championship, resulting in a total of 427 and 292 players being involved in the two tournaments, respectively. In the 44 and 29 games covered in the two tournaments a total of 412 and 284 players were involved, respectively. Therefore, the injury incidence for the World Cup, per player for all injuries was 27.7% (8.0% and 19.7% as a result of a foul and no foul, respectively), with moderate injuries representing 4.1% (0.7% and 3.4% as a result of a foul and no foul, respectively) of the total. The injury incidence for the European Championship, per player for all injuries was 28.1% (7.7% and 20.4% as a result of a foul and no foul, respectively), with moderate injuries representing 4.3% (0.4% and 3.9% as a result of a foul and no foul, respectively) of the total.

2.3.1.4 Injury frequency rates

From the number of moderate and minor injuries recorded during the two tournaments, the average frequency of injuries with respect to an individual team and an individual player can be calculated (Table 2.2).

For the determination of IFR, it was assumed that there were 100 minutes in each standard game, 130 minutes in games where extra time was played (except the European Championship final in which 105 minutes was played due to the 'golden goal' ruling), and that 22 players were involved at all times. This gives the total equivalent playing hours of 1657 and 1109 hours for the World Cup and European Championship, respectively, resulting from the 44 and 31 games analysed in the tournaments.

Table 2.2: Average injury frequency rates for each team and individual players during the 1994 World Cup Finals and the 1996 European Championship Finals.

	<i>Fouls</i>				<i>No fouls</i>			
	<i>Minor</i>		<i>Moderate</i>		<i>Minor</i>		<i>Moderate</i>	
	<i>WC</i>	<i>Euro</i>	<i>WC</i>	<i>Euro</i>	<i>WC</i>	<i>Euro</i>	<i>WC</i>	<i>Euro</i>
	'94	'96	'94	'96	'94	'96	'94	'96
<i>Team</i>								
Number of injuries/team-game	0.34	0.36	0.03	0.02	0.76	0.81	0.16	0.19
Number of games for one team								
player to be injured	2.9	2.8	29.3	58.0	1.3	1.2	6.3	5.3
<i>Player</i>								
Number of injuries/player-game	0.031	0.033	0.003	0.002	0.069	0.074	0.014	0.017
Number of games for an individual								
player to be injured	32.3	30.6	322.7	638.0	14.4	13.6	69.1	58.0

From equation 2.1 the IFR's per 100,000 playing hours were calculated for both minor and moderate injuries where fouls and no fouls were indicated during both tournaments (Table 2.3).

Table 2.3: Injury frequency rates per 100,000 playing hours during the 1994 World Cup Finals and the 1996 European Championship Finals.

	<i>Injuries/100,000 hours</i>			
	<i>Minor</i>		<i>Moderate</i>	
	<i>WC '94</i>	<i>Euro '96</i>	<i>WC '94</i>	<i>Euro '96</i>
Resulting from fouls	1811	1894	181	90
Not resulting from fouls	4043	4238	845	992
<i>Total</i>	5854	6132	1026	1082

The overall injury frequency rate was 6880 and 7214 injuries per 100,000 hours played during the World Cup and European Championship, respectively.

2.3.2 Division One and the Premiership

Division One league matches were analysed over 3 competitive seasons from August 1994 through to May 1997, while Premiership matches were observed from the 1996/1997 playing season. The number of games analysed for each season is shown in Table 2.4 together with the total number of free-kicks and treatments that occurred during those games.

Table 2.4: Number of games analysed, free-kicks and injuries observed from Division One and Premiership football.

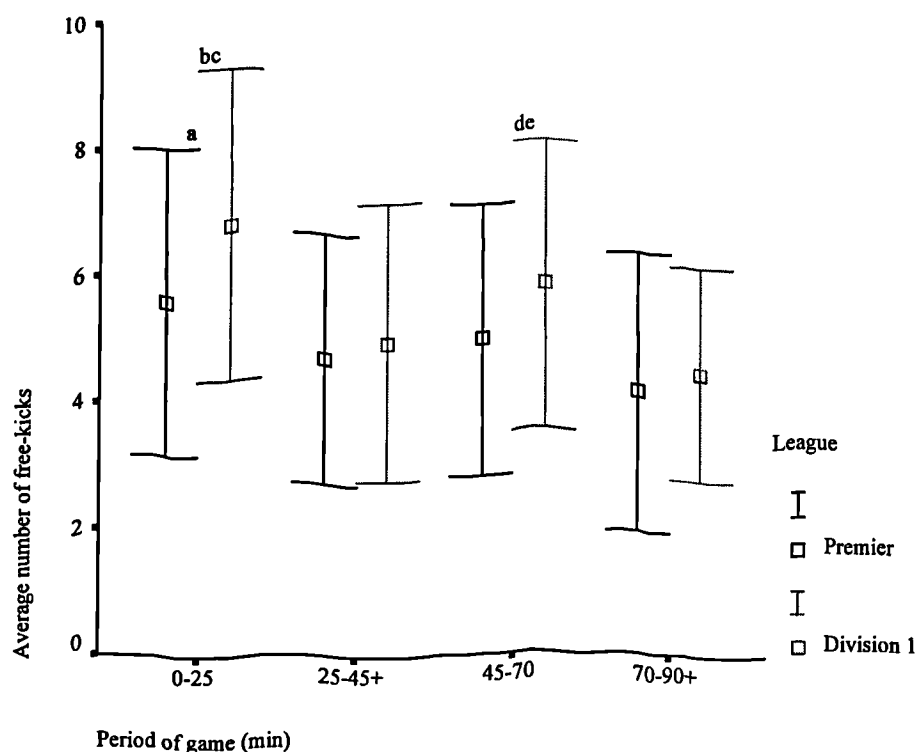
<i>Year + division</i>	<i>Number of games</i>	<i>Free-kicks</i>	<i>Treatments</i>	<i>Free-kick injuries</i>	<i>No free-kick injuries</i>
'94/'95 Div 1	26	571	77	14	63
'95/'96 Div 1	27	604	73	22	51
'96/'97 Div 1	40	873	92	25	67
'96/'97 Prem	49	998	95	17	78

The average number of free-kicks per game was not found to differ over the three competitive seasons for Division One, with the Premiership matches showing a tendency to produce a lower number compared to all Division One matches (20.4 ± 5.4 vs 22.0 ± 5.0 , NS). The Division One matches produced a total of 242 treatments made up of 61 (25%) as a result of a foul, two incidents resulting in two players being treated in both cases, compared to a greater number of 181 (75%) where no foul had been committed ($P < 0.01$), incidents resulting in the treatment of two players each in eleven cases. Of the 61 treatments associated with free-kicks 84% were administered to the perpetrator himself, and 16% to the victim. During the one Premiership season analysed there was a total of 95 treatments, composed of 17 (18%) as the result of a foul, zero incidents resulting in two players being treated, compared to a greater number of 78 (82%) where no foul had been committed ($P < 0.01$), incidents resulting in the treatment of two players each in three cases. Of the 17 treatments associated with free-kicks 94% were administered to the perpetrator himself, and 6% to the victim. Statistically significant differences were not observed in the total number of treatments, the number of treatments where a free-kick was awarded or those where no free-kick was given, between the individual Division One seasons analysed. In addition to the 337 treatments described above there were 47 other instances throughout the analysed games (22 during the 1996/1997 Premiership season, and 12, 3, and 10 from the 1994/1995, 1995/1996, and 1996/1997 Division One seasons, respectively), where players were judged to be injured, being substituted without receiving treatment during the course of the game. Of these injuries none could be associated with a foul and as the timing and mechanisms of these injuries were not known they could not be used in many of the analyses performed.

2.3.2.1 Fouls and injuries

The average number of free-kicks awarded throughout each match for each league analysed are shown in Figure 2.6, with Table 2.5 displaying the average number of player treatments for each period. During the Premiership matches a greater number of free-kicks ($29 \pm 12\%$) occurred in the first 25 minutes (0-25 min vs 25-45+ min and 70-90+ min, $P < 0.05$), although there was no

difference between the two halves ($52 \pm 17\%$ vs $48 \pm 17\%$, NS). The same pattern was shown during the Division One matches, a greater number of the free-kicks ($31 \pm 11\%$) occurring in the first 25 min (0-25 min vs 25-45+ min, 45-70 min and 70-90+ min, $P < 0.01$, $P < 0.05$ and $P < 0.01$, respectively). Other differences were found between the second and third quarters and the third and final quarters ($P < 0.05$ and $P < 0.01$, respectively); a difference was found between the two halves ($53 \pm 16\%$ vs $47 \pm 14\%$, $P < 0.01$).



- ^a $P < 0.05$ 0-25 min vs 25-45+ min and 70-90+ min
- ^b $P < 0.01$ 0-25 min vs 25-45+ min and 70-90+ min
- ^c $P < 0.05$ 0-25 min vs 45-70 min
- ^d $P < 0.05$ 45-70 min vs 25-45+ min
- ^e $P < 0.01$ 45-70 min vs 70-90+ min

Figure 2.6: Number of 'free-kicks' during Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches in each quarter of the game (mean $\pm$ SD).

The total number of treatments during each quarter of the game was not found to differ in the Premiership matches, however the first 25 minutes of the second half was found to give rise to the greatest amount of treatments in the Division One matches ($32 \pm 35\%$), based on the average from the three seasons analysed (45-70 min vs 0-25 min, $P < 0.05$), contributing to a greater number of treatments in the second half ($56 \pm 38\%$ vs $44 \pm 45\%$, $P < 0.05$). Although no statistically significant differences were shown between the Division One and Premiership matches between game quarters, the total number of treatments were different (2.60 ± 1.59 vs 1.94 ± 1.56 , respectively, $P < 0.05$); a greater number of treatments was also found in the second

half of Division One matches compared to those in the Premiership (1.46 ± 1.17 vs 0.84 ± 0.99 , respectively, $P < 0.01$).

Table 2.5: Average number of treatments in each quarter of the game during Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches with respect to refereeing decision.

<i>Time (min)</i>	<i>0-25</i>		<i>25-45+</i>		<i>45-70</i>		<i>70-90+</i>	
	<i>Prem</i>	<i>Div 1</i>	<i>Prem</i>	<i>Div 1</i>	<i>Prem</i>	<i>Div 1</i>	<i>Prem</i>	<i>Div 1</i>
Free-kick	0.02 ^a	0.18	0.08 ^a	0.20 ^a	0.08 ^b	0.15 ^a	0.16	0.12 ^a
No free-kick	0.49	0.31 ^c	0.51	0.44	0.29 ^d	0.69	0.31	0.51
<i>Total</i>	0.51	0.49 ^c	0.59	0.64	0.37	0.84	0.47	0.63

^a $P < 0.01$ Free-kick treatments vs No free-kick treatments

^b $P < 0.05$ Free-kick treatments vs No free-kick treatments

^c $P < 0.05$ 0-25 min vs 45-70 min

^d $P < 0.05$ Premiership vs Division One

Treatments where no free-kicks were awarded also showed differences between the two leagues. Firstly, the Premiership did not display any differences between game quarters although the number of treatments was greatest in the first half ($63 \pm 64\%$ vs $37 \pm 55\%$, $P < 0.05$). Secondly, the Division One matches showed the reverse, the greatest number of treatments ($35 \pm 44\%$) occurring during the first 25 minutes after half time (45-70 min vs 0-25 min, $P < 0.05$), 61 ($\pm 55\%$) of the 'no free-kick' treatments taking place during the second half which was greater than the first half ($39 \pm 45\%$, $P < 0.01$). The result was that Division One matches produced a greater number of treatments where no free-kick was awarded than games in the Premiership over several time periods (45-70 min: 0.69 ± 0.85 vs 0.29 ± 0.58 , $P < 0.05$; 2nd half: 1.19 ± 1.07 vs 0.59 ± 0.84 , $P < 0.01$).

Player treatments involving the referee awarding a free-kick were not found to differ between quarters or halves during Division One or Premiership matches. Although differences between the Division One and Premiership matches were observed in the total number of treatments where a free-kick was awarded (0.66 ± 0.81 vs 0.35 ± 0.60 , respectively, $P < 0.05$), no differences were found between quarters or halves.

With regards to differences between the number of treatments that were not the result of a foul compared to those incidents leading to treatments that were deemed to contravene the laws of the game, differences were observed over several game periods in both leagues; Division One produced differences in both halves and all quarters except the first ($P < 0.01$), while differences in the Premiership were found in both quarters of the first half ($P < 0.01$), the third quarter

($P < 0.05$), and the first and second half ($P < 0.01$ and $P < 0.05$, respectively).

Player position was not deemed to be a significant factor in the injury incidence in either the Premiership matches or those from Division One, assuming the same formation as that described for the international tournament matches. Neither were the ratio of injuries from fouls compared to other causes found to show any significant differences between playing positions.

2.3.2.2 Accident ratio triangles

From the data it was not possible to construct accident triangles identical to those produced for the international football analyses. Due to differences in the media coverage and the time span involved in the domestic football analyses it was not possible to distinguish between 'moderate' and 'minor' injuries, the accident triangles thus being constructed on two levels.

All 'injuries'

There were a total of 117 moderate and minor injuries, and 981 'no injury' (fouls) incidents recorded during the Premiership matches. The equivalent numbers for the Division One matches were 267, and 1987, respectively. Therefore, for every moderate or minor injury there were 8 and 7 incidents which could potentially have led to an injury during the Premiership and Division One matches, respectively (Figure 2.7).

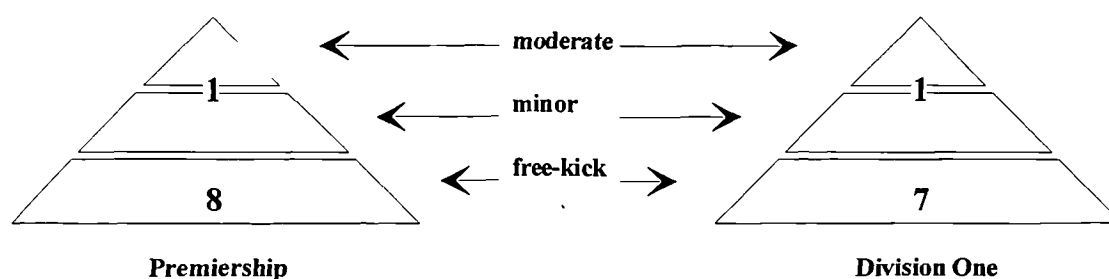


Figure 2.7: Accident ratios for all injuries with respect to potential incidents during Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

These results can be sub-divided into two categories: those injuries resulting from fouls and those where no foul was committed.

'Injuries' resulting from fouls

From the 998 fouls recorded during the Premiership matches, 17 incidents resulted in either moderate or minor injuries. There were 61 incidents which resulted in a moderate or minor injuries during the Division One matches, these occurring from the 2048 fouls recorded. This produced accident ratios of 1:59 and 1:34 for the Premiership and Division One, respectively, as shown in Figure 2.8.

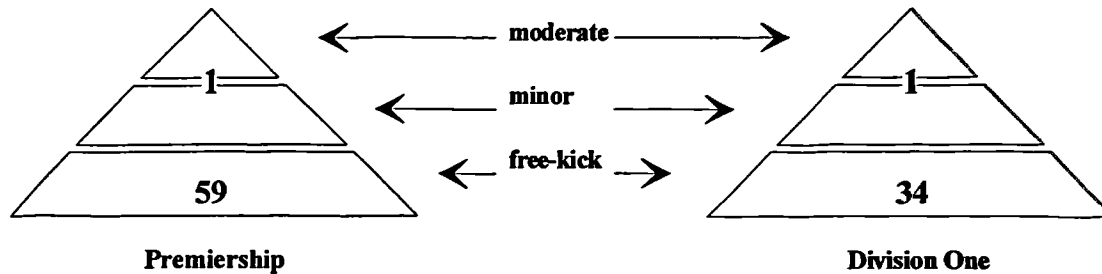


Figure 2.8: Accident ratios for injuries resulting from fouls with respect to potential incidents during Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

'Injuries' not resulting from fouls

During the Premiership matches there were 100 injuries judged to be at least moderate or minor. Seventy-eight of them received treatment during the game, the remainder did not. Two hundred and six injuries were judged to be at least minor or moderate during the Division One matches, of which 181 received treatment during the game, the remainder did not. By normalising the results on the injuries resulting from fouls in the respective leagues, figures of 6 and 3 moderate or minor injuries during the Premiership and Division One were produced, respectively (Figure 2.9), i.e. for every moderate or minor injury that was the result of a foul there are 6 and 3 similar injuries in Premiership and Division One matches, respectively, that are not the result of a foul. Possible underlying causes of these injuries are discussed later.

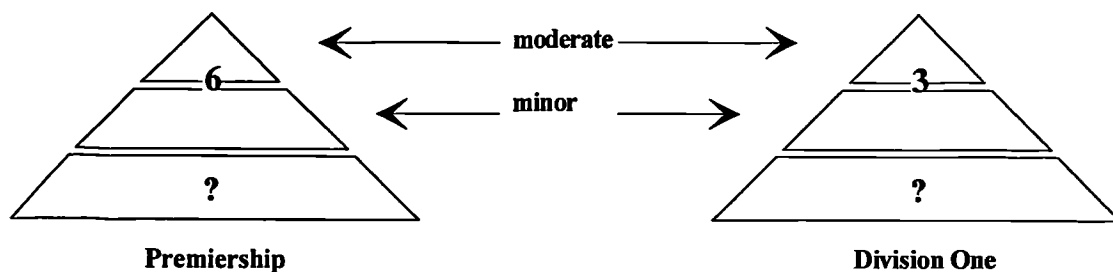


Figure 2.9: Accident ratios for injuries where no fouls were committed during the Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

2.3.2.3 Injury incidence rates

Assuming each of the 49 matches analysed during the 1996/1997 Premiership season had twenty-two players involved and that the same player did not play more than once, a total of 1078 players participated in the analyses. Based on the same principle for the 93 Division One matches analysed, 2046 players were calculated to have played. Therefore, the injury incidence for the Premiership matches, per player for all injuries was 10.9% (1.6% and 9.3% as a result of a foul and no foul, respectively), with the injury incidence for Division One, per player for all injuries was 13.0% (3.0% and 10.0% as a result of a foul and no foul, respectively).

2.3.2.4 Injury frequency rates

From the number of moderate or minor injuries recorded during matches from the two leagues, the average frequency of injuries with respect to an individual team and an individual player can be calculated (Table 2.6).

Table 2.6: Average injury frequency rates for each team and individual players during the Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

	<i>Fouls</i>		<i>No fouls</i>	
	<i>Prem</i>	<i>Div 1</i>	<i>Prem</i>	<i>Div 1</i>
<i>Team</i>				
Number of injuries/team-game	0.17	0.33	1.02	1.11
Number of games for one team				
player to be injured	5.8	3.0	1.0	0.9
<i>Player</i>				
Number of injuries/player-game	0.016	0.030	0.093	0.101
Number of games for an individual				
player to be injured	63.4	33.6	10.8	9.9

For the determination of IFR, it was assumed that there were 100 minutes in each league game, and that 22 players were involved at all times. This gives the total equivalent playing hours of 1797 and 3410 hours for the Premiership and Division One matches, respectively.

From equation 2.1 the IFR's per 100,000 playing hours were calculated for injuries where fouls and no fouls were indicated during both tournaments (Table 2.7).

Table 2.7: Injury frequency rates per 100,000 playing hours during the Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

	<i>Injuries/100,000 hours</i>	
	<i>Prem</i>	<i>Div 1</i>
Resulting from fouls	946	1789
Not resulting from fouls	5565	6041
<i>Total</i>	6511	7830

The overall injury frequency rate was 6511 and 7830 injuries per 100,000 hours played during the Premiership and Division One matches analysed, respectively.

2.4 Discussion

Previous research on football injuries has in most cases been based on youth^{66, 69, 76, 156} or semi-professional football^{15, 54, 157}. Other information has been obtained from hospital medical records^{32, 40} and insurance claims³³. In the cases of hospital records and insurance claims, detailed information concerning minor injuries is unavailable and with information from the lower levels of football, the exercise intensity is less, with the number of physical contacts fewer compared to higher levels of competition¹⁵³; consequently the risk of injury may be lower. The main objective of this Chapter was to address the issues of injury frequency and severity at several levels of competition; international, English Premiership and English Division One. In this respect, the 1994 World Cup Finals and the 1996 European Championships provided an ideal opportunity to observe and record a large number of competitive games involving the best twenty-four national teams in the world and best sixteen in Europe, respectively, at the time. With the comprehensive media coverage, much information was obtained which otherwise would only be available from working directly with the teams. Similarly, football coverage from both BSkyB Television and ITV provided live domestic games throughout the playing seasons with full information available on players taking part.

Injury Causation

All injuries and treatments were divided into those resulting from a foul and those which were not. However, one problem was that the cause of some reported injuries could not be identified; some players possibly received an injury without receiving treatment and played on. Seventy-seven players were identified as having sustained an injury during a game (22, 10, 20, and 25 during the World Cup, European Championships, Premiership and Division One games, respectively), without receiving treatment during the game, of which only one was the result of a foul. There were though a further 74 instances throughout the two international tournaments (34 and 40 during the World Cup and European Championships, respectively), where players may have received minor or moderate injuries, during training or games, resulting in the players missing games due to their injuries. These were not included in the analyses and, together with other training and playing injuries not reported during both the international and domestic matches, it is probable that there may be an underestimation of the level of injury. This hypothesis is supported in a study by Jorgensen⁶⁸, where 47% of reported injuries did not receive medical attention but were still defined as being a handicap or preventing participation altogether.

From the three levels of football observed, of all treatments received on the pitch between 18%

and 35% were found to be the result of a foul (18 $\pm$ 31% Premiership; 25 $\pm$ 31% Division One; 30 $\pm$ 7% European Championships; 35 $\pm$ 7% World Cup). This is similar to the level obtained by other investigators ^{34, 40, 55, 56, 68} who have reported that fouls were responsible for 15-28% of game injuries. The total number of free-kicks was found to vary between levels with matches from the English leagues producing fewer free-kicks than the international matches ($P < 0.01$). Possible contributory factors include: the highly competitive nature of the international matches, the internationals being part of a unique tournament and therefore players being prepared to take more risks during these matches; the referees in the two tournaments being given strict guidelines to adhere to; the different styles of play that international teams utilise possibly leading to a greater number of player contacts, although one may expect less difference in styles in the European tournament compared to the World Cup. The European Championship matches however, produced a greater number of free-kicks than the World Cup as well as the domestic matches ($P < 0.01$), the heat in the USA most likely being an influential factor, and also the requirement for referees in the European Championship to maintain the refereeing standards set in the World Cup two years earlier. No strong correlations were found however between free-kicks and injuries at any level, coefficients of determination being less than 22%, which is not surprising considering the percentages of injuries reported that were not the result of a foul. Also, based on the accident ratios only 1.7-3.0% of fouls committed actually lead to a player requiring treatment, no differences being observed between the international and domestic matches. Moderate injuries during the World Cup and European Championships, respectively, were found to occur 5 and 11 times more frequently without a foul being involved than being the result of one; moderate and minor injuries during the Premiership and Division One matches, respectively, were found to occur 6 and 3 times more frequently without a foul being involved than being the result of one.

Where an injury results from a foul then the cause of the injury can be easily identified. Between 57% and 82% of these recorded treatments at the three competitive levels were due to players sustaining an injury when being tackled, the free-kick being awarded in favour of the injured player in no fewer than 97% of those cases at each level. The laws of the game are written to protect players from such incidents and the few injuries sustained from foul play compared to other causes seems to suggest that the current laws act as a deterrent and are being properly enforced. There are occasions though where no fouls have been deemed by the referee to have been committed but injuries still arise. The immediate causes of these are not always identifiable; however of the 446 injuries analysed (minor and moderate) in this category, 60% were associated with contact with another player, 17% did not involve another player and in 23% of the cases an immediate cause could not be established from the information available. The equivalent values for the individual competitions are shown in Table 2.8. Supplementary

information however does suggest that the number of non-contact injuries is an underestimate since in the majority of those injuries where no immediate cause was established, many players leave the field of play without being treated, these injuries already having been established as not being the result of a foul.

Table 2.8: Injury causation where no fouls were committed during the 1994 World Cup Finals, the 1996 European Championships, Division One matches from 1994 to 1997 and the 1996/1997 Premiership matches.

<i>Competition</i>	<i>Injury causation (%)</i>		
	<i>Player to player contact</i>	<i>No player to player contact</i>	<i>Not established</i>
WC '94	49	20	31
Euro '96	62	16	22
Div 1	67	16	17
Prem	60	15	25

An analysis of the events leading to the player to player contact injuries is shown in Figure 2.10. The high number of injuries arising from player to player contacts, which were not deemed to be fouls, gives some cause for concern and is worthy of further investigation to determine whether minor changes to the laws of the game could reduce this figure. It is important, however, that the epidemiology and severity of these injuries are first determined so that any need to reduce these injuries can be assessed. Overall, 68% (66% Premiership; 74% Division One; 64% European Championships; 59% World Cup) of the observed injuries involved player to player contact which is slightly above the results reported by other researchers; Hoff and Martin⁶⁶ reported 66%, Sandelin et al.³³ 52%, and Anglietti et al.⁷³ 38%. This is to be expected considering the criteria used for determining an injury in the current analysis and the higher level of competition involved.

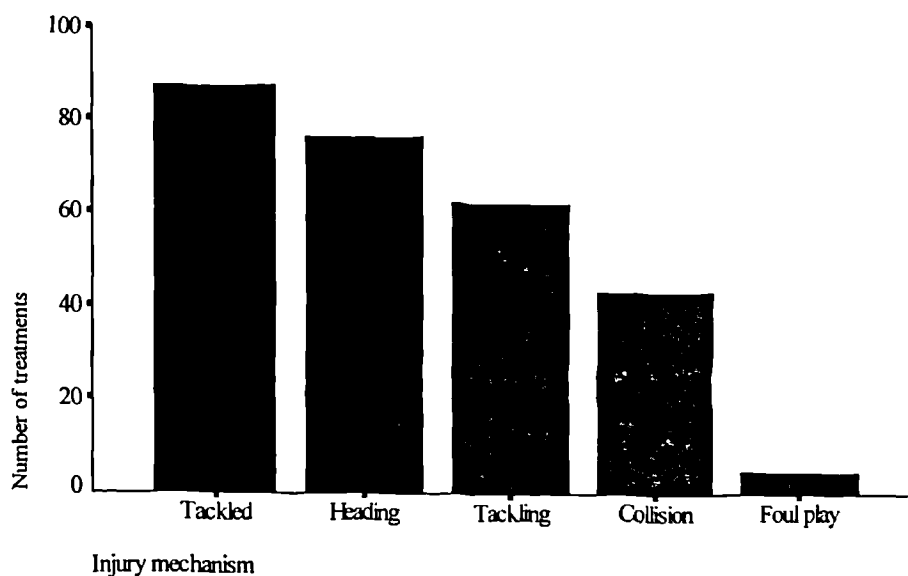


Figure 2.10: Mechanisms of the player to player contact injuries during matches where no fouls were committed at all competitive levels.

With respect to player position and injury only the World Cup showed one position to be more at risk to injury than others ($P < 0.05$). In this particular analysis 43% of injuries were sustained by defenders, indicating that they are subjected to a greater risk of injury than other players, a finding similar to that of Hunt and Fulford ¹⁵⁷, who reported that defenders sustained 55% of 200 injuries researched. Ekstrand and Gillquist ⁵⁴, however, did not find any difference in the incidence of injury between playing positions. Comparisons of different investigations are difficult owing to the different designs and populations under study, but the high injury incidence amongst defenders in the World Cup could well be attributed to the attacking football that was encouraged through the FIFA directives at the time and the necessity for defenders to take greater risks, and be more reactive, to prevent attacking situations developing and goals being scored. However the same pattern was not reported in the European Championships. Considering the four different analyses together no one position was found to be more injury prone at one level compared to another.

Injuries were more common in the 2nd half of matches compared to the first during the World Cup and Division One matches ($P < 0.05$), 35 ($\pm 41\%$) and 32 ($\pm 35\%$) occurring in the first 25 minutes after half time, respectively. Although the time of day of the games during the World Cup had no effect on the number of injuries, heat stress could well have been a contributory fatiguing factor as several games were played in excess of 100°F. Possible explanations for the injury pattern observed in the Division One matches could be based upon fitness parameters, the players from the lower level being more prone to fatigue and during the half-time interval, being less likely to maintain their body in a state of readiness for the second half. However, without

details on the mechanism and aetiology of injuries it is not possible to make informed judgements. A difference in injury incidence in the second half of matches was found between levels, Division One teams sustaining more injuries in the 25 minute period after half time compared to the Premiership teams (0.84 ± 0.91 vs 0.47 ± 0.65 , respectively, NS), subsequently leading to a difference in the second half as a whole (1.46 ± 1.17 vs 0.84 ± 0.99 , respectively, $P < 0.01$). The total number of injuries was also found to be greater in the Division One matches compared to the Premiership ($P < 0.05$), possible explanations being based on the same principles above, the Premiership players being less susceptible to fatigue. This contradicts the findings of previous research^{32, 33, 55, 71}, injury incidence having been reported to increase with the level at which the game is played; however, again the criteria upon which an injury is documented in the current work must be considered. It is possible that at the lower levels of competition there are a greater number of contacts between players (Division One matches showing a tendency (NS) to produce a greater number of free-kicks than Premiership matches, with injuries resulting from free-kicks being greater in the former, $P < 0.05$). This together with the greater number of contact injuries recorded in this study, where no foul was deemed to have occurred (Table 2.8), produce many recordable injuries which would probably not have been categorised in others. The severity of the injuries received e.g. in terms of days absent from training/matches, must be known. It is worth noting that players, who appear to be injured and leave the field of play without receiving treatment, have injuries which tend to be more severe; although there was less than half the number of Premiership matches analysed compared to Division One the number of cases where this was the case was similar in the two leagues, suggesting that a higher percentage of more severe injuries occur at the higher level.

Injury Frequency Rates

For each team the average injury incidence for moderate injuries was 113 and 126/1000 game hours during the World Cup and European Championships, respectively; this is lower than the 300/1000 game hours reported in Sweden by Ekstrand and his colleagues¹⁵. However, as discussed above, the figures reported in this study are considered to be conservative as there may be injuries which have not been identified. Additionally, the Swedish study included all injuries causing the player to miss the next game or practice session whereas it was only the next game in the current study. The overall injury frequency rates per 1000 player hours were not found to differ between international tournaments and domestic leagues (range 65.1-78.3 injuries/1000 player hours). The total injury incidence was 27.7% and 28.2% per player during the World Cup and European Championships, respectively, these figures are within the range reported by Jorgenson⁶⁸ and Hoy et al.⁴⁰ of 36% and 18%, respectively. The injury incidence rates for the Premiership and Division One were 10.9% and 13.0%, respectively, and values for the World Cup and European Championships based on the same principle were 11.8% and 12.5%.

respectively. For 'moderate' injuries alone the incidence was 4.1% and 4.3%, respectively, for the World Cup and European Championships, which can be compared to 'over 3-day injuries' reportable under RIDDOR; based on these calculations it could be assumed that similar incidence rates for 'moderate' injuries would be seen in the Premiership and Division One. The highest incidence of these reportable (over 3-day) injuries in industry is for open cast coal workings, where there is an incidence rate of 4.4% per employee per year, whilst the average rate for all industries is 0.7% per employee per year ⁷.

Industrial accident frequency rates in the UK are normally reported as accidents per 100,000 working hours. The industrial category of accidents resulting in more than 3 days absence from work can be considered equivalent to the 'moderate' category used in this study of football injuries, and examples of these are compared in Table 2.9.

Table 2.9: Industrial accidents ⁷ and football injuries per 100,000 working and playing hours, respectively.

<i>Employment category</i>	<i>Accidents/incidents per 100,000 working/playing hours</i>	
	<i>'Over 3-day injuries'</i>	<i>Missing at least one game</i>
Open cast coal workings	1.8	-
Construction	0.6	-
Banking and finance	0.04	-
Professional football (international)	-	1048

Compared to the accident statistics issued by the Health and Safety Commission the injury frequency rates in football are three orders of magnitude higher than in many industries. Put in another context, based on the frequency of football injuries, the average person who works a 40 hour week in industry would expect to obtain a moderate injury and be absent from work for at least 3 days every third week.

Accident ratios reported by the HSE ¹⁴⁸ for a range of industrial case studies can be conveniently compared with the accident triangles produced in this study. The four HSE studies produced an average accident ratio of over 3-day injury accidents:first aid only:non-injury accidents of 1:7:189 with a range of 1:4:126 to 1:10:195. Although the absolute values vary, the ratios produced are comparable to the figures of 1:6:73 observed during the World Cup and 1:6:82 observed during the European Championships. The figures of 73 and 82 (non-injury incidents) only take account of the number of free-kicks since the number of potential incidents could not be calculated for injuries where no fouls were committed.

Strengths and Weaknesses of the Examination of Injuries and Incidents via Matches

The analysis of televised matches provides an easy access to a large number of games at a highly competitive level, together with a varying degree of media coverage. A form of expediency sampling was implemented, the matches selected being entirely restricted to those broadcasted, preventing any other kind of sampling procedures from being implemented, all matches at the different competitive levels broadcasted being analysed. Televised matches allow accidents and incidents on the field of play to be looked at closely, with the ability to review incidents at varying speeds if required. The construction of accident triangles allows comparisons to be made to statistics from other industries, the data from the match analysis providing a source of information for the lower levels of the accident triangle in terms of potential incidents and minor injuries, however with regards to the more severe injuries this technique is limited. Analysis of the two international tournaments did to some extent provide an insight into the more severe injuries that occur while playing football, however several inadequacies remain. It is immediately apparent that of those injuries that are documented the true extent of many of them are not known with little epidemiological data being made available. The injury mechanisms of those players who are treated on the field of play not having been involved in any player to player contact are extremely difficult to identify. Many injuries must also go unnoticed; players may sustain an injury during the course of a game and play through to the end without receiving any treatment on the field of play or they may be substituted without showing any signs of an injury. These situations are difficult to identify and without close co-operation with the teams themselves it is not possible to establish the true extent of the incidence of injury in professional football. Further, this process provides no indication as to the injury problems that take place during training, either during the pre-season period or the playing season. For these reasons there is a necessity for the injury epidemiology at professional football clubs to be researched in depth, which should not only supplement the match analysis data but provide a more complete appreciation of the incidence and severity of injuries in professional football.

CHAPTER 3

A PROSPECTIVE EPIDEMIOLOGICAL STUDY OF INJURIES IN PROFESSIONAL FOOTBALL

3.1 Introduction

The analysis of the frequency and severity of injuries during competitive matches from video recordings (Chapter 2) allows some incidents to be looked at in depth, however, the mechanism of injuries sustained where no player to player contact has occurred are difficult to identify accurately. Also, the true extent of many of the injuries can not be identified and not all injuries can be observed. This method of analysis is limited in the collection of *epidemiological injury* data during matches and gives no indication of the injury incidence during training. The aim of this chapter is to establish the epidemiological injury status in English professional football during both matches and training.

Football is known to be associated with a relatively high injury rate^{19, 77}, the features being outlined in several epidemiological studies^{20, 32, 33, 39, 40, 53-55, 57, 58, 69-72, 76, 87}. However, investigations into the pattern of adult football injuries have in the majority been undertaken retrospectively being based on casualty records^{3, 33, 39-52}, and these, together with the few prospective studies have not involved professional football. Also, many studies are biased by selection with respect to age, gender and competition level. Notwithstanding this the research does imply that football injuries are indeed a problem and that preventive action is necessary.

For injury prevention to be effective knowledge of the aetiological factors that influence injury are required. The epidemiology and aetiology of football injuries do most probably differ though between different football populations. Different selected homogenous subgroups of the football population in Sweden and Denmark found different types of prevention to be successful in reducing the incidence and severity of football injuries³¹. Thus, there does appear to be a need to identify the high risk groups and their respective dependent and independent variables.

In England the professional football schedule is very demanding and somewhat different to other footballing nations. The competitive season commences in August, following 4-8 weeks of pre-

season training, with 1st teams playing between 50 and 60 games before the end of the season in May. In addition to this several players will have international duty and will subsequently be involved in summer tournaments such as the European Championship and the World Cup. It would appear therefore that epidemiological and aetiological injury data in this culture is necessary before improvements regarding the prevention of injuries can be made.

It seems evident that as there are few studies involving professional football, and since comparisons are made difficult due to results being biased by injury definition, research design and selection of material, it is important that each footballing nation and subgroups within each football population conduct their own assessments of the risks of injuries and ill-health to professional footballers. To ensure the health and safety of professional footballers efforts must be made to prevent and control injuries. For this to be possible data must be made available via an effective injury surveillance system, one where the data is valid and reliable. The correct use of this data is aimed to prevent potential hazards arising and reduce the severity of those that take place. It is anticipated that the epidemiological data obtained from the current study will not only aid professional football clubs in complying with current health and safety legislation but provide insight into the aetiology of injuries in English professional football, identifying particular areas that warrant further study and preventive intervention.

3.2 Methodology

3.2.1 Data Collection

Player injuries were prospectively reported from November 1994 through to the end of the 1996/1997 playing season, with seven professional clubs taking part during the study. All professional players were involved and the youth players from two clubs formed part of the study sample. The player population at each club ranged from 28 to 44 players, the number varying throughout the study due to player transfers.

All injuries were diagnosed and recorded on a specific injury report form (Appendix 2) by the respective club physiotherapist who was either Chartered or FA qualified. It was therefore assumed that injuries were reported consistently, the injury report form being designed to provide an objective record of injuries which was easy to complete. A recordable injury was defined as one that 'was received during normal practice or a competitive game and prevented the injured party from participating in normal practice for at least one day, not including the day of the injury'. Analysis did not include colds or sickness, or any other condition requiring

examination from a GP. The following variables were identified for each injury:

- The date of the injury
- The venue where the injury took place
- The type of surface on which the injury took place
- The condition of the playing surface
- The squad number of the injured player
- The number of times the player had been injured during the study
- The playing position at the time of injury
- The nature of the injury
- The anatomical location of the injury
- The side of the body where the injury is located
- Playing involvement after initial injury
- Whether the injury was a re-injury
- The severity of the injury
- The activity at the time of the injury
- The time of the injury
- The injury mechanism
- The refereeing decision if applicable
- The type of shoes worn
- Whether shin-pads were worn or not

The severity of an injury was defined as 'slight', 'minor', 'moderate', or 'major' depending on whether the player was absent from training or competition for 1 to 3 days, 4 to 7 days, 1 week to 1 month, or greater than 1 month, respectively. The day in which the player gained the injury did not count towards the number of days absent.

The total number of competitive games played by each club (1st team, reserves, and youth where applicable) over the study period were recorded together with the date of each individual game; pre-season matches, friendlies and testimonial matches were not included and were considered to be part of the training programme. Playing hours at risk during training were calculated for each club by extrapolating the hours trained during one typical week during the season to the whole of the playing season. Similarly, the playing hours at risk during competitive games were calculated for each club, assuming there were eleven players from the club on the pitch at all times and that each match lasted 100 minutes. The risk of injury was calculated as a rate per 1000 playing hours in games and training. Although the extrapolation method of calculation could lead to an overestimation or an underestimation of injury incidence in training, depending on how the training schedule analysed differs throughout the season for each club, the data will enable adequate comparisons to be made between the risk of injury during training and competitive matches.

3.2.2 Statistical Analysis

Data were analysed using SPSS. In performing statistical analyses the chi-square significance test was used to investigate differences between the following variables: the number of injuries

in training and matches; the number of match injuries occurring when playing at home compared to away; the activity conducted at the time of training injuries; the body side location (dominant vs non-dominant) of all injuries and separately for both training and match injuries; the removal of injured players immediately, later or not at all for all injuries and separately for both training and match injuries; the number of injuries in training compared to matches with respect to nature, location, mechanism, severity, re-injuries, body side, the removal of players and footwear; the severity of all injuries with respect to the nature, location, mechanism, refereeing decision, playing position and the removal of injured players; the type of footwear used during training with respect to the nature, location and mechanism of training injuries; the number of match injuries with respect to player position; player position and the nature, location, mechanism and refereeing decision of match injuries; the time of match injuries; the time of match injuries with respect to nature, location, mechanism and refereeing decision; anterior and posterior thigh strains for all injuries and separately for both training and match injuries; the total number of injuries per month and separately for both training and match injuries; the nature and location of re-injuries. The above variables were repeatedly analysed to investigate differences between clubs, within clubs for all injuries, within clubs between seasons and between youth and senior squads, and injuries between all youth and senior players. The Kolmogorov-Smirnov test was used where expected frequencies were less than 5. Statistical significance was accepted at the $P < 0.05$ level. Values are reported as mean ($\pm$ SD).

3.3 Results

3.3.1 Overview

During the period of study 824 injuries were recorded that prevented a player from either training or playing for at least one day. This did not include players who were unable to play or train due to illness or other non-playing causes of absence. Two-thirds of the injuries occurred during competitive matches, the remainder taking place during regular training.

3.3.1.1 Nature of injuries

The nature of the injuries sustained during training and matches are shown in Table 3.1. Eighty-one percent of all the injuries were classified as either strains, sprains or contusions, over half of these being muscular strains. Injuries grouped as 'others' in Table 3.1 include abrasions, concussions, dislocations, disc derangements and meniscal tears, no individual category amounting to more than 2% of all injuries. When examining the injuries in training and matches

separately, the three major types of injury already mentioned remained dominant in each situation, however, the two proportions were different. A greater relative proportion of contusions in matches compared to training and strains during training compared to matches were observed ($P<0.01$).

Table 3.1: Nature of injuries sustained during training and matches.

<i>Nature</i>	<i>All injuries</i>		<i>Match injuries</i>		<i>Training injuries</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Strain	338	41	192	35 ^a	146	53
Sprain	167	20	115	21	52	19
Contusion	165	20	143	26 ^a	22	8
Overuse	33	4	22	4	11	4
Fracture	30	4	22	4	8	3
Laceration	19	2	16	3	3	1
Other	72	9	39	7	33	12
<i>Total</i>	824	100	549	100	275	100

^a $P<0.01$ Relative proportion of match injuries vs Relative proportion of training injuries

3.3.1.2 Location of injuries

The location of injuries sustained by players are shown in Table 3.2, which indicates that the lower extremity was the site of most injuries: of the 87% of injuries located in the lower extremity, 23% involved the thigh, 17% the ankle and 14% the knee. Of the injuries to the thigh 81% were muscular strains, a greater number (64%) of which were to the posterior aspect rather than the anterior ($P<0.01$). Of the injuries to the knee 45% were ligament sprains, 76% of which were to the medial collateral ligament and 14% were not specified. Of the injuries to the ankle 75% were ligament sprains. When comparing injuries in training to those sustained during matches the most common injury location remained the thigh, their relative proportions being similar (22% and 24%, respectively, NS); during matches the difference between the posterior and anterior aspect of the thigh with regard to strains remained ($P<0.01$), although an equal number of strains to each aspect was sustained during training. There were differences between the relative proportions of several injury locations in the two situations, matches producing a greater relative proportion of injuries to the head and foot than training ($P<0.05$), and a greater relative proportion of back injuries occurring in training compared to matches ($P<0.01$) with a tendency (NS) for a greater proportion of injuries to the lower leg during training than matches; there were a greater proportion of anterior thigh strains in training compared to matches ($P<0.01$), no differences being found concerning muscular strains to the posterior aspect of the

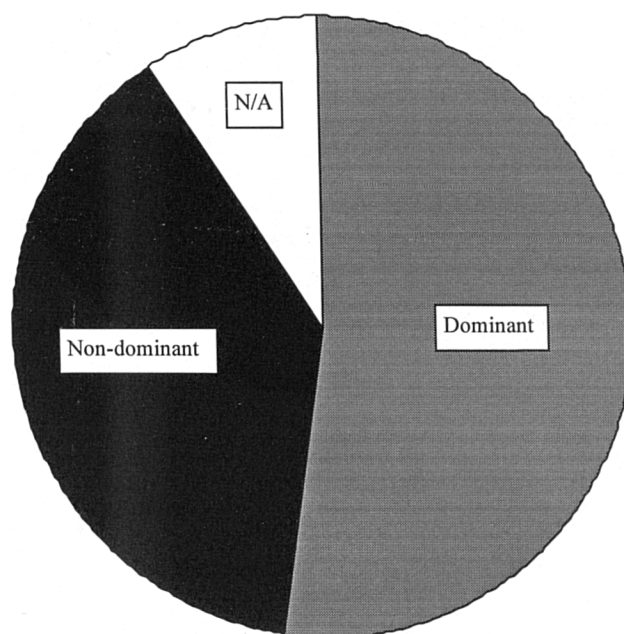
thigh.

Table 3.2: Location of injuries sustained during training and matches.

<i>Location</i>	<i>All injuries</i>		<i>Match injuries</i>		<i>Training injuries</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Thigh	187	23	121	22	66	24
Ankle	138	17	94	17	44	16
Knee	113	14	77	14	36	13
Lower leg	104	13	60	11	44	16
Groin	93	11	60	11	33	12
Torso	60	7	33	6	27	10
Foot	51	6	43	8 ^a	8	3
Head/face/neck	30	4	27	5 ^a	3	1
Upper extremity	25	3	17	3	8	3
Hip	23	3	17	3	6	2
<i>Total</i>	824	100	549	100	275	100

^a $P < 0.05$ Relative proportion of match injuries vs Relative proportion of training injuries

Figure 3.1 represents the total number of injuries with respect to the side of the body that was injured. From the 824 injuries recorded 9.1% of the injury sites could not be classified with respect to body side with the number of injuries to the players' dominant body side being greater than those to the non-dominant (52.3% vs 38.7%, $P < 0.01$). This difference remained for both training and match injuries ($P < 0.01$), no differences being observed between the relative proportions of the body side of injury in training and matches compared to the average for all injuries.



a

^a $P < 0.01$ Dominant vs Non-dominant

Figure 3.1: Percentage distribution of the total number of injuries with respect to injured body side.

3.3.1.3 Mechanism of injuries

The injury mechanisms are shown in Table 3.3, the most frequent being when a player was tackled (23%), while injuries as a result of making a tackle were accountable for 14% of the total number of injuries. These injury mechanisms involved player to player contact, however, frequent non-contact injury mechanisms included running, shooting, turning and overuse, their overall percentages being 19%, 10%, 8% and 8%, respectively. The mechanisms of injuries during matches and training differed considerably; the player to player contact mechanisms of tackling and being tackled were greater relatively during matches than was observed during training ($P < 0.01$) as were heading injuries and those resulting from a collision ($P < 0.05$); the non-contact mechanisms of running, shooting and turning dominate the training injuries, greater relative proportions of injuries being observed than during matches ($P < 0.01$).

Table 3.3: Mechanism of injuries sustained during training and matches.

<i>Mechanism</i>	<i>All injuries</i>		<i>Match injuries</i>		<i>Training injuries</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Tackled	192	23	159	29 ^a	33	12
Running	154	19	82	15 ^a	72	26
Tackling	112	14	93	17 ^a	19	7
Shooting	83	10	33	6 ^a	50	18
Turning	66	8	28	5 ^a	38	14
Overuse	65	8	49	9	16	6
Landing	39	5	28	5 ^b	11	4
Collision	31	4	28	5 ^b	3	1
Heading	19	2	16	3	3	1
Jumping	19	2	11	2	8	3
Other	44	5	22	4	22	8
<i>Total</i>	824	100	549	100	275	100

^a P<0.01 Relative proportion of match injuries vs Relative proportion of training injuries^b P<0.05 Relative proportion of match injuries vs Relative proportion of training injuries

33.1.4 Severity of injuries

Table 3.4 displays the severity of all the injuries, 73% being classified as either minor or moderate, with a further 11% preventing the injured player from training or playing for at least one month. There were differences between match and training injuries in terms of time absent, a greater relative number of slight injuries as a result of playing a competitive match compared to training being observed (P<0.01).

Table 3.4: Severity of injuries sustained during training and matches.

<i>Nature</i>	<i>All injuries</i>		<i>Match injuries</i>		<i>Training injuries</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Slight	134	16	104	19 ^a	30	11
Minor	286	35	176	32	110	40
Moderate	310	38	203	37	107	39
Major	94	11	66	12	28	10
<i>Total</i>	824	100	549	100	275	100

^a P<0.01 Relative proportion of match injuries vs Relative proportion of training injuries

In 44% of the total number of match injuries the player involved was not removed from the field of play, 32% were removed immediately while the remainder were removed later as a

consequence of the sustained injury (Figure 3.2). The severity of the injuries where players were either removed immediately or not at all in matches were different to the severity seen for all match injuries ($P<0.01$); where players were removed immediately injuries were more severe, as shown by a greater proportion of moderate and major injuries, whereas those injuries where the player was not removed from the pitch produced relatively more slight and minor injuries, although there were still 24 injuries that were major. For the training injuries 60% and 22% of the players were taken out of training immediately and later, respectively, the remainder continuing through to the end of the session (Figure 3.2); the same tendencies (NS) as was observed with the removal of players from matches were shown, a difference with regards to injury severity only being reported where players were not removed from training ($P<0.01$). Considering the removal of players for all injuries, differences were observed where players were removed immediately and not at all, the former being greater in training than average and the latter being greater in matches ($P<0.01$).



Figure 3.2: Competitive match and training injuries to players and their subsequent removal.

The severity of a two types of injuries were found to differ from the proportions observed for all injuries. Contusions resulted in a greater proportion of slight injuries than average ($P<0.01$) whereas fractures produced a greater proportion of major injuries ($P<0.01$). In terms of anatomical location of injury, the face, knee and ankle produced differences in the proportion, major injuries being more than twice than the average in knee injuries ($P<0.01$) with ankle injuries having a greater proportion of moderate injuries ($P<0.05$); injuries to the face produced more slight injuries in relative terms than was observed from the overall injury severity ($P<0.05$). With regards to the injury mechanism there were a more than average percentage of minor injuries as a result of shooting with less being classified as slight ($P<0.05$), while heading injuries resulted in a greater proportion of slight injuries than average ($P<0.05$).

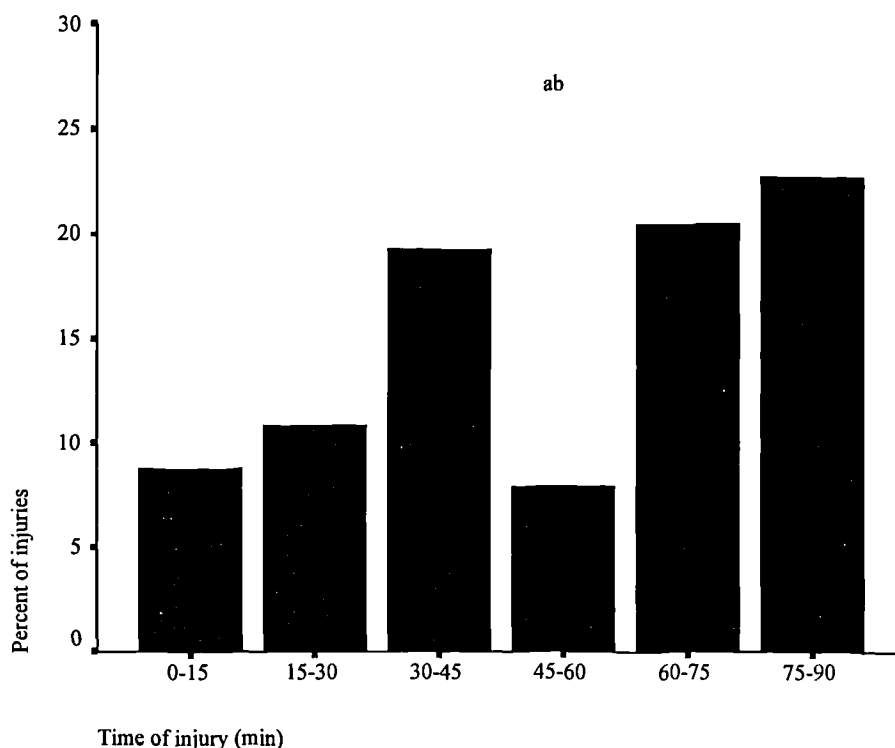
3.3.1.5 Equipment and conditions

The type of footwear used during training and matches was found to differ ($P<0.01$). Of all the injuries in the study players were reported to be wearing studded boots in 72% of the cases, 24% wearing moulded boots with the remainder being other types of footwear. For competitive match injuries and training injuries these percentages changed to 91% and 9%, and 33% and 56%, respectively. For training injuries it was found that of the 36 injuries to the knee 87% of the injured players were wearing moulded boots, this being greater than the average of 56% ($P<0.01$). No significant differences were observed between the incidence of different injury variables and the playing surface on which the injury took place or its condition.

3.3.1.6 Match injuries

Sixty-seven percent of all the injuries occurred during competitive match play. Based on the 1:4:4:2 (goalkeeper, defenders, midfielders, forwards) playing system used by the majority of the teams involved in the study, a difference was found between the observed and expected incidence of injury. Goalkeepers and midfield players sustained proportionately fewer injuries than expected while for defenders and forwards the converse was true (3% vs 9%, 42% vs 36%, 32% vs 36% and 23% vs 18%, respectively, $P<0.01$). Also, the ratio of injuries arising from where a foul was committed against the injured player showed differences between playing positions. Defenders sustained fewer injuries as a result of a foul than expected (22% vs 42%, $P<0.05$), with both midfield players and forwards sustaining a greater number than expected ($P<0.05$). No differences were observed between the ratios of those injuries in which a free-kick was awarded against the perpetrator, where no foul was deemed to have occurred or where there was no contact with another player at the time of injury and the playing position of injured player. From the 405 match injuries where the refereeing decision was recorded, 18% were the result of a foul, 86% of which were caused by the opponent. Based on the severity of the competitive match injuries already documented, no differences were found in the severity of the subsequent injury whether or not a foul, for or against, was committed at the time of the injury. No differences were observed between playing positions and severity of competitive match injuries. With regards to the nature, location and mechanism of injuries, defenders were found to sustain proportionately more strain injuries and injuries from tackling than any other player (48% vs 36% and 53% vs 36%, respectively, $P<0.01$), attackers sustained proportionately more contusions and were injured as a result of being tackled proportionately more frequently than other playing positions (28% vs 18% and 33% vs 18%, respectively, $P<0.01$), and both defenders and attackers were more commonly involved, proportionately, in collisions resulting in injuries than other players (51% vs 36% and 26% vs 18%, respectively, $P<0.01$).

The distribution of the competitive match injuries with respect to time are represented in Figure 3.3. From the 480 injuries for which the time of injury was known there was a greater than average frequency of injuries observed during the final 15 minutes of the first half and the final 30 minutes of the second (P<0.01). Despite the increase in injury incidence towards the latter stages of the first half there remained a greater number of injuries recorded in the second half compared to the first (57% vs 43%, P<0.01). Based on the timings of the match injuries the nature, location, and mechanism of injuries, and the refereeing decision made were not found to differ from the observed frequencies, despite 42% of the injuries that resulted from shooting having occurred during the final 15 minutes of matches.



^a P<0.01 Difference between match periods

^b P<0.01 0-45 min vs 45-90 min

Figure 3.3: Percentage of competitive match injuries with respect to the time of incident.

The venue at which the competitive match was played, either being home or away, had no effect on the incidence of injury, 52% of the competitive match injuries being received while playing away from home, the remainder taking place while playing at home.

3.3.1.7 Training injuries

Thirty-three percent of all the injuries took place during regular training. Seventy-six percent of these training injuries occurred either during small sided games or 11-a-side practice games, the

remainder taking place during specific exercises or drills.

Of the 275 training injuries recorded, 86% of the players were not wearing any kind of shin-pad at the time of their injury, the lower leg or ankle being the site of 32% of these injuries. Contusions and fractures only accounted for 11% of the training injuries where shin-pads were not worn, however of these 42% were either to the lower leg or ankle.

3.3.1.8 Re-injuries

Re-injuries were accountable for 22% of all the injuries sustained during the study period. The likelihood of sustaining a similar injury to a previous one was found to be more likely, during regular training than during a competitive match ($P < 0.05$), based on the observed proportions of injuries in each of the playing situations already shown. The number and percentage of injuries that were and were not re-injuries are shown in Table 3.5.

Table 3.5: Injuries and their relation to whether or not they were a recurrence.

<i>Injury type</i>	<i>All injuries</i>		<i>Match injuries</i>		<i>Training injuries</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Re-injury	178	22	104	19 ^a	74	27
New injury	632	76	434	79	198	72
Unknown	13	2	11	2	2	1
<i>Total</i>	824	100	549	100	275	100

^a $P < 0.05$ Relative proportion of match injuries vs Relative proportion of training injuries

Of the 178 re-injuries that were documented, 75% were either strains or sprains (48% and 27%, respectively). The location of these injuries are shown in Table 3.6; of the 34 thigh strain re-injuries 82% were to the posterior aspect.

Table 3.6: Anatomical location of recurrent strain and sprain injuries.

<i>Location</i>	<i>Strains</i>		<i>Sprains</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Thigh	34	40	-	-
Ankle	-	-	33	70
Groin	26	30	-	-
Lower leg	18	21	-	-
Knee	-	-	11	24
Others	8	9	3	6
<i>Total</i>	86	100	47	100

Based on the observed frequencies of re-injuries it was found that the incidence of recurrent ankle sprains was greater than the average (32% vs 22%, $P < 0.05$). A tendency for the re-injuries to be more severe than other injuries was observed, however no statistical significance was reported.

3.3.2 Club Analysis

From the seven football clubs involved in the study only four were involved for a consecutive period which spanned beyond a duration of greater than one year. As a consequence of this only the results from these four clubs are considered individually. The number of injuries sustained by these clubs totalled 744, representing 90% of all the injuries in the study. Using these results collectively, since data concerning player exposure and the number of matches played were only available from these clubs, some analysis were better performed using this data rather than all the injuries sustained.

The level at which the clubs played varied; club A spent one season in Division One and another in the Premiership, club B spent over one and a half seasons in Division One and one season in Division Two, club C remained in Division One throughout the study, and club D was in the Premiership throughout the study period.

Injury incidence

A summary of the number of players exposed to injury, the number of matches played and hours spent training per week are shown in Table 3.7.

Table 3.7: Summary of individual club characteristics.

<i>Club</i>	<i>Period (wks)</i>	<i>Number of players</i>		<i>Number of matches</i>			<i>Training (hrs/wk)</i>
		<i>Pros</i>	<i>Youth</i>	<i>1st</i>	<i>Reserve</i>	<i>Youth</i>	
A	82	30	14	94	62	75	5.5
B	114	24	-	155	87	-	4.5
C	106	26	-	138	82	-	6.0
D	105	28	16	120	85	85	4.5

The observation period involved the players completing a total of 983 competitive matches, with each squad training an average of five hours per week. There was an average of 138 players exposed to injury at any one time over a study period totalling 13720 player weeks. Assuming there were eleven players on the pitch for each team throughout all competitive matches, each game lasting 100 minutes, and that all the players took part in regular training, the total number

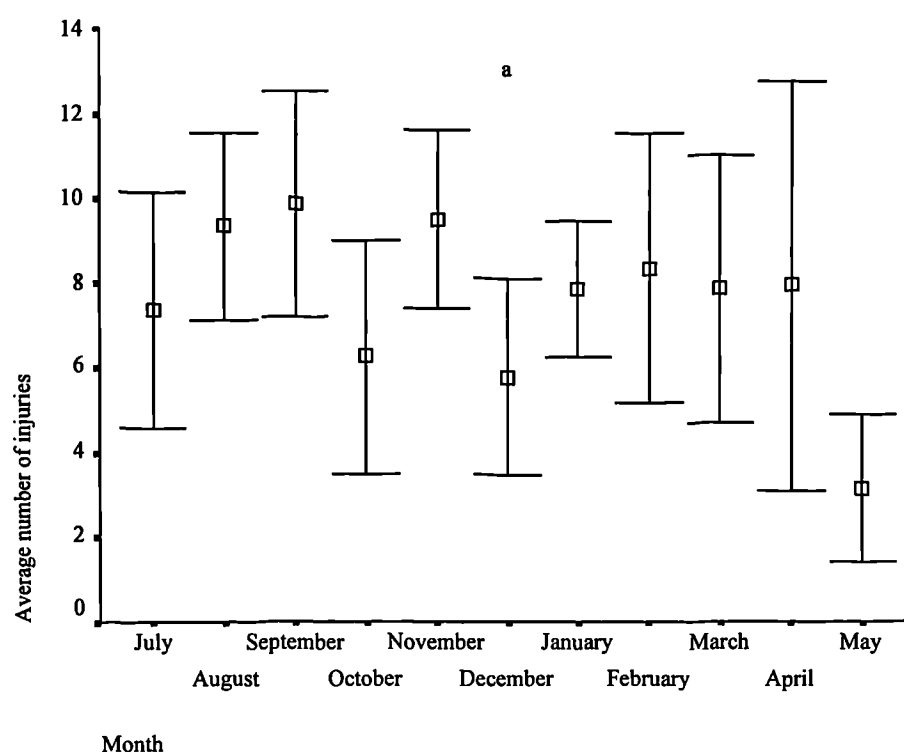
of hours players were exposed to injury was 87504; 69482 hours and 18022 hours during training and matches, respectively. The total injury rate for all four clubs was 8.5/1000 hours; 27.7/1000 hours and 3.5/1000 hours during matches and training, respectively. This information is summarised in Table 3.8.

Table 3.8: Number and rate of injuries sustained during training and matches for each club.

Club	Number of injuries			Injury rate per 1000 hours		
	Total	Match	Training	Total	Match	Training
A	180	119	61	7.5	28.1	3.1
B	128	83	45	7.6	18.7	3.7
C	187	145	42	9.1	36.0	2.5
D	249	153	96	9.5	28.8	4.6

Monthly distribution

The average number of injuries sustained per month by players at each of the four clubs over the study period is shown in Figure 3.4.

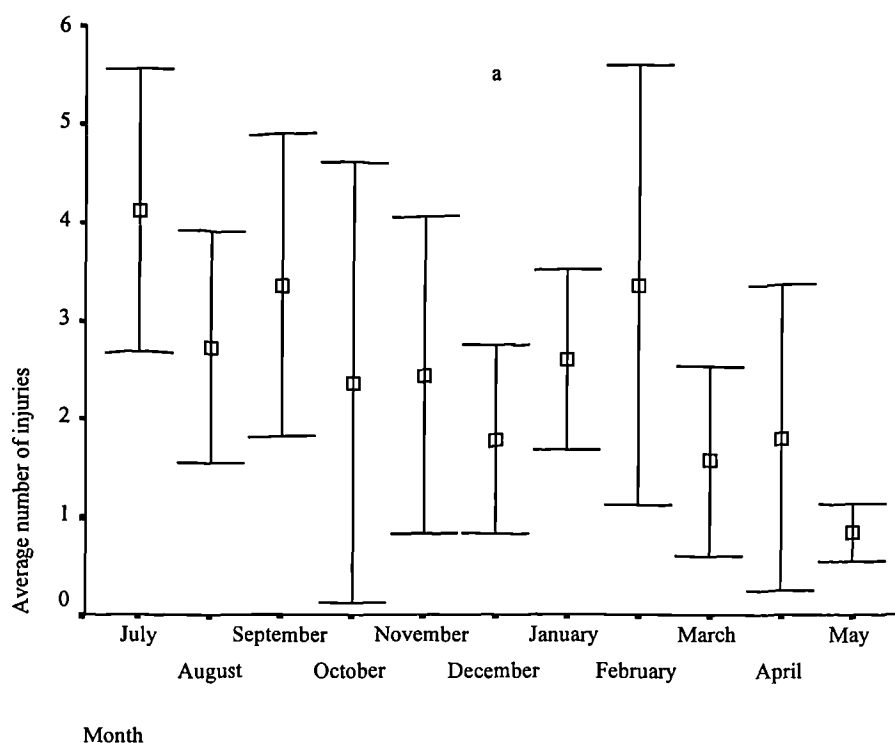


^a P<0.05 Difference between months

Figure 3.4: Number of injuries sustained at each club per month (mean ±SD).

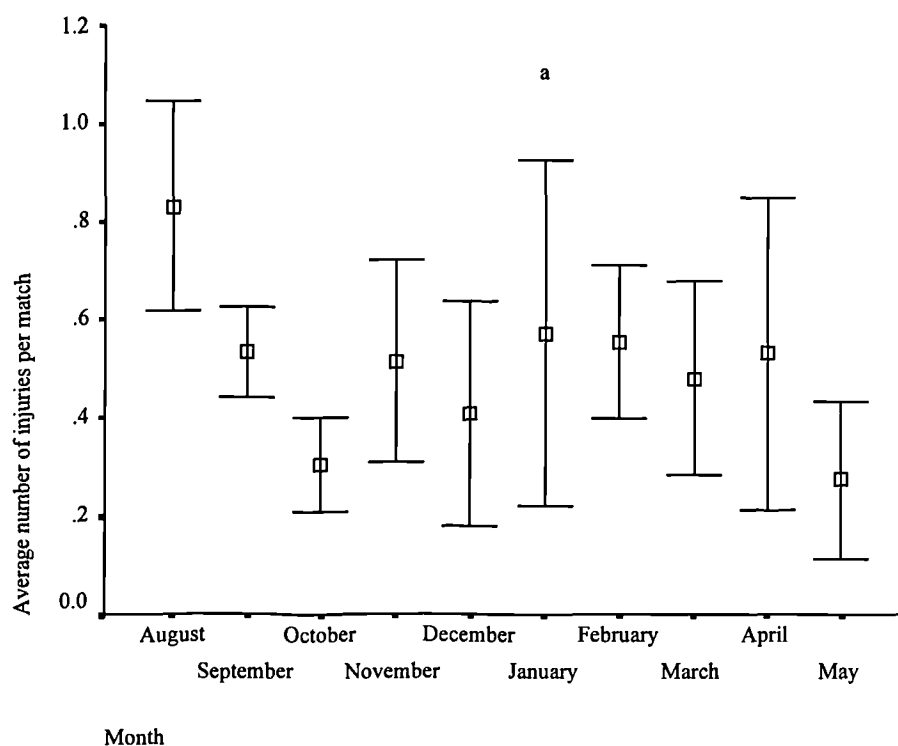
Not accounting for the month of May where data is only collected for part of the month as the season ends partly through this month, differences in the number of injuries sustained between months were observed ($P<0.05$); two peaks are identifiable, one occurring during the early months of the playing season while the other extends over the final few months at the end of the season.

Figures 3.5 and 3.6 show the average number of training injuries sustained at each club per month and the average number of injuries sustained during matches per match per month at each club, respectively. It can be seen that the number of injuries sustained during training gradually decreases throughout the season, the injury incidence being different between months ($P<0.05$); the highest incidence rate occurred during pre-season, before peaking again slightly in January and February. With regards to the number of match injuries the greatest injury incidence occurred during the month of August ($P<0.05$), the incidence remaining fairly consistent throughout the remainder of the playing season.



^a $P<0.05$ Difference between months

Figure 3.5: Number of training injuries sustained at each club per month (mean $\pm$ SD).



^a $P < 0.05$ Difference between months

Figure 3.6: Number of match injuries sustained at each club per match played in each month (mean $\pm$ SD).

Missed training/match days

The total number of injuries that prevented players from participating in regular training or matches for a certain number of days is represented in Figure 3.7. The majority of the injured players return to normal practice within 3 weeks, several peaks being observed within this time frame; at 4 days, 7 days, 13-15 days and 19 days missed.

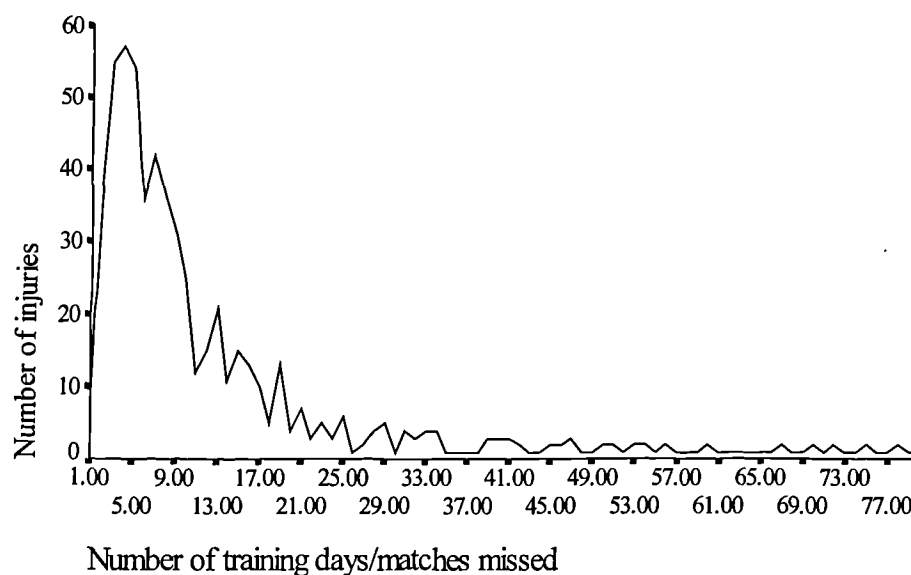


Figure 3.7: Total number of training/match days missed for each injury over 2 seasons at 4 clubs.

The total number of days that players were absent from regular training or matches during 2 seasons for 4 of the clubs involved in the study are shown in Table 3.9. The total number of days that players were absent over one full season ranged from 504-1651 days, producing an average of 1103 (± 370) days absence for each club. During each season analysed the percentage number of players from each club to sustain an injury ranged from 86-100%.

Table 3.9: Total and mean ($\pm$ SD) number of days absent through injury for 4 clubs over 2 seasons.

<i>Club</i>	<i>Year</i>	<i>Division</i>	<i>Mean (days)</i>	<i>Total (days)</i>
A	1995/1996	One	14 (± 14)	1288
	1996/1997	Premier	19 (± 24)	1651
B	1995/1996	One	22 (± 32)	1100
	1996/1997	Two	13 (± 11)	504
C	1995/1996	One	16 (± 43)	1001
	1996/1997	One	10 (± 13)	707
D	1995/1996	Premier	11 (± 12)	1159
	1996/1997	Premier	14 (± 17)	1411

3.3.2.2 Inter-club analysis

Differences were found between the four clubs in the percentage of injuries sustained during training, clubs C and D obtaining, proportionately, less and more injuries, respectively, based on the total number of injuries recorded at each club ($P < 0.05$); club C sustained more injuries in matches than in training compared to the proportion seen for all four clubs ($P < 0.01$), while club

D showed a tendency (NS) to sustain a greater number of injuries in training. The training activity at the time of injury was also found to differ between clubs; small-sided games produced a greater proportion of injuries for both clubs C and D ($P<0.01$), whilst 11-a-side practice games produced a greater proportion of injuries for club B based on the total number of training injuries recorded at each club, 60% rather than 18% of the injuries sustained during this activity being attributed to this club ($P<0.01$).

With regards to the nature, location and mechanism of injuries different proportions were found between clubs. Although there were only 14 injuries classified as being a disc derangement, 70% were sustained at club C ($P<0.01$). The only other injury found to be significantly different, statistically, between clubs was overuse; these injuries were infrequently reported at club D with only 5% of this type of injury being found ($P<0.05$). No statistical significant differences were reported in terms of the nature of match or training injuries between clubs, although there was a tendency in training for clubs A and D to sustain fewer (9% vs 25%, NS) and greater (54% vs 39%, NS) sprain injuries, respectively, based on each club's proportion of training injuries. Based on the ratio of injuries sustained during matches and training at each individual club several types of injury were found to show a difference; all clubs sustained a greater number of contusions during matches than the average (clubs A, B and D, $P<0.05$; club C, $P<0.01$), more strain injuries took place during training at clubs A and D than the average ($P<0.05$), and sprains were more common at club A during matches ($P<0.05$). This information is summarised in Tables 3.10a and 3.10b.

Table 3.10a: Nature of injuries sustained during matches at each club.

<i>Nature</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Strain	38	32	26	31	56	39	55	36
Sprain	25	21	18	22	28	19	30	20
Contusion	34	29	19	23	31	21	44	29
Overuse	8	7	5	6	10	7	1	1
Fracture	3	2	7	9	3	2	7	4
Laceration	3	2	2	2	2	1	8	5
Other	8	7	6	7	15	10	8	5
<i>Total</i>	119	100	83	100	145	100	153	100

Table 3.10b: Nature of injuries sustained during training at each club.

<i>Nature</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Strain	34	56	21	47	23	55	50	52
Sprain	4	7	9	20	8	19	25	26
Contusion	6	10	3	7	1	2	13	14
Overuse	5	8	5	11	3	7	1	1
Fracture	0	0	1	2	1	2	1	1
Laceration	0	0	0	0	0	0	1	1
Other	11	19	6	13	6	14	5	5
<i>Total</i>	61	100	45	100	42	100	96	100

The only injury location reported to have different injury proportions between clubs was the knee; club D was found to have fewer knee injuries, proportionately, while the reverse was true for club B (24% vs 33% and 27% vs 17%, respectively, $P < 0.05$). The same was true for match injuries ($P < 0.05$), while injuries to the foot were also found to be different between clubs ($P < 0.05$). The proportion of training injuries in terms of injury location were not found to be significantly different, statistically, between clubs. Looking at clubs individually, club D sustained a greater relative proportion of injuries to the foot during matches compared to training ($P < 0.01$). This is summarised in Tables 3.11a and 3.11b.

Table 3.11a: Location of injuries sustained during matches at each club.

<i>Location</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Thigh	28	24	15	18	33	23	33	22
Ankle	26	22	13	16	22	15	21	14
Knee ^a	19	16	20	24	21	14	16	10
Lower leg	10	8	7	8	21	14	20	13
Groin	7	6	8	10	20	14	16	10
Torso	6	5	7	8	14	10	6	4
Foot ^a	6	5	9	11	6	4	18	12
Head/face/neck	10	8	2	3	4	3	10	7
Upper extremity	3	3	1	1	2	1	7	4
Hip	4	3	1	1	3	2	6	4
<i>Total</i>	119	100	83	100	145	100	153	100

^a $P < 0.05$ Different proportions between clubs

Table 3.11b: Location of injuries sustained during training at each club.

<i>Location</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Thigh	18	29	8	18	10	24	25	26
Ankle	7	12	7	16	6	14	20	21
Knee	12	20	10	22	3	7	11	11
Lower leg	8	13	9	20	4	10	16	17
Groin	7	12	5	11	7	17	10	10
Torso	3	5	3	7	7	17	11	11
Foot	2	3	2	4	1	2	2	2
Head/face/neck	2	3	0	0	1	2	0	0
Upper extremity	0	0	1	2	3	7	1	1
Hip	2	3	0	0	0	0	0	0
<i>Total</i>	61	100	45	100	42	100	96	100

No differences were observed between clubs with regard to the location of the injured body side. Assuming a 1:1 ratio between injuries to the dominant and non-dominant sides differences were found at individual clubs; both clubs A and D sustained a greater number of injuries to the player's dominant side ($P<0.01$ and $P<0.05$, respectively), the same tendency being shown in both training and matches for club D (NS) and just in training for club A ($P<0.01$).

The injury mechanisms were found to show differences between clubs; injuries caused by overuse were more common at club C ($P<0.01$), injuries resulting from turning and shooting being greater proportionately at clubs A and D, respectively, with club C showing fewer injuries from these mechanisms ($P<0.01$), and the proportion of injuries sustained while running were greater at club B ($P<0.05$). For match injuries the difference between clubs remained for those caused by overuse ($P<0.01$), whilst the same was true for turning and running injuries during training ($P<0.05$ and $P<0.01$, respectively), club D sustaining fewer injuries while running during training. Based on the ratio of injuries sustained during matches and training at each individual club several injury mechanisms were found to differ; clubs A, B and C were all found to sustain a greater proportionate number of injuries in training compared to matches as a result of running ($P<0.05$, $P<0.01$ and $P<0.05$, respectively) and in matches compared to training as a result of being tackled ($P<0.05$). Clubs A and D sustained a greater proportion of injuries in matches as a consequence of tackling and collisions, respectively ($P<0.05$), whilst training injuries through turning were more common in clubs A and D ($P<0.01$), as was the case concerning shooting with the latter club ($P<0.01$), the same tendency (NS) being found in club B. Tables 3.12a and 3.12b summarise this information.

Table 3.12a: Mechanism of injuries sustained during matches at each club.

<i>Mechanism</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Tackled	41	35	25	30	37	26	42	27
Running	14	12	17	20	20	14	24	16
Tackling	20	17	14	17	22	15	22	14
Shooting	12	10	6	7	4	3	12	8
Turning	9	8	5	6	5	3	4	3
Overuse ^a	4	3	3	4	31	21	9	6
Landing	4	3	1	1	11	8	12	8
Collision	9	8	2	2	2	1	12	8
Heading	3	2	4	5	4	3	3	2
Jumping	0	0	4	5	1	1	4	3
Other	3	2	2	2	8	5	9	6
<i>Total</i>	119	100	83	100	145	100	153	100

^a P<0.01 Different proportions between clubs**Table 3.12b:** Mechanism of injuries sustained during training at each club.

<i>Mechanism</i>	<i>Club A</i>		<i>Club B</i>		<i>Club C</i>		<i>Club D</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Tackled	9	15	5	11	3	7	16	17
Running ^a	17	28	22	49	13	31	17	18
Tackling	2	3	3	7	2	5	10	10
Shooting	10	16	6	13	5	12	22	23
Turning ^b	14	23	2	4	2	5	13	14
Overuse	6	10	1	2	6	14	4	4
Landing	0	0	3	7	3	7	3	3
Collision	2	3	0	0	0	0	1	1
Heading	0	0	0	0	1	2	1	1
Jumping	0	0	2	4	1	2	1	1
Other	1	2	1	2	6	14	8	8
<i>Total</i>	61	100	45	100	42	100	96	100

^a P<0.01 Different proportions between clubs^b P<0.05 Different proportions between clubs

Differences in the severity of injuries sustained between clubs were found; the incidence of slight injuries was proportionately greater at club C, with clubs A and B sustaining proportionately fewer (P<0.01), this difference being attributed to injuries sustained during

matches ($P<0.01$) rather than training (NS). No differences were reported between clubs in the severity of training injuries. The ratios of the severity of injuries in training to those in matches were not found to differ at individual clubs from the ratios observed for all individual club injuries.

The proportion of re-injuries that each club sustained during the study was found to be greater in club C with both clubs A and D showing a lower proportion, based on the total number of injuries at each club ($P<0.01$). This was the same for re-injuries that occurred during matches ($P<0.01$), no differences being observed between clubs in the proportion of re-injuries that took place during training. Looking at clubs individually, only club D was found to sustain a greater relative proportion of re-injuries in training compared to matches ($P<0.01$).

Based on a 1:4:4:2 playing formation, in competitive matches forwards were reported to be injured more often at clubs A and B, less being reported at clubs C and D ($P<0.05$); no other differences between clubs and player position were documented. Analysing clubs individually, clubs A and B both found defenders and forwards to sustain a greater proportion of injuries than expected from the assumed playing formation ($P<0.05$ and $P<0.01$, respectively), whilst only defenders were more injury prone at club C ($P<0.01$). Compared to the severity of injuries seen at each individual club, no differences were observed in the severity of the injuries for each playing position.

Whether or not injured players were removed from the field of play was found to vary between the four clubs; a higher proportion of injured players were not removed at all at club C, the reverse being the case at club A ($P<0.01$), whereas when players were removed immediately, higher proportions were found at clubs A and D, clubs B and C tending not to remove injured players immediately ($P<0.01$). For those injuries that took place during matches the same patterns were seen for club A, fewer players not being removed at all with more being removed immediately ($P<0.05$ and $P<0.01$, respectively). Significant differences were also reported between clubs in the removal of injured players from training; clubs A and D were found to remove proportionately more players either immediately or later compared to club C who did not remove injured players at all on a proportionately more regular basis ($P<0.01$). Comparing the removal of injured players in training to those in matches at clubs individually produced similar patterns between several clubs; clubs A, B and D all kept a greater proportion of players on the field of play following an injury in matches compared to training ($P<0.01$), whereas club C removed a greater proportion of their players later during a match compared to training ($P<0.05$). A greater proportion of players were removed immediately during training than matches at clubs C and D ($P<0.01$) with club B showing the same tendency (NS).

During competitive matches different clubs were found to sustain a different proportion of injuries in several time periods; in the first and final 15 minutes clubs D and A, respectively, sustained a greater proportion of injuries, based on the total number of match injuries at each club ($P<0.05$ and $P<0.01$, respectively). Assuming that the expected frequency of injuries is equal throughout a match only club C failed to show any significant differences between time periods, although the same tendencies (NS) were shown as those observed for club D; a greater proportion of injuries occurred during the final 30 minutes of matches and in the last 15 minutes of the first half, with fewer injuries taking place in the first 15 minutes after the interval ($P<0.01$). Clubs A and B both sustained a greater proportion of injuries in the final 15 minutes of both halves, the former also sustaining slightly more than expected between 60-75 minutes ($P<0.01$).

3.3.2.3 Intra-club analysis

Between seasons (1995/1996 and 1996/1997)

Differences within clubs from one season to the next were observed in several of the injury parameters documented. Based on the ratio of the total injuries at each club for the 1995/1996 season to the 1996/1997 season, differences in the injury activity were observed at club D; differences were present in both the number of injuries occurring in training and matches, less injuries in training taking place during the 1996/1997 season ($P<0.05$) and a greater number of match injuries occurring during the same season ($P<0.01$). The difference in the number of training injuries observed between seasons was due to a greater relative proportion of injuries during small-sided games in the 1995/1996 season ($P<0.05$). No differences were observed in any other clubs.

The nature of injuries at two clubs were reported to differ. Club C sustained a greater proportion of overuse injuries in the 1996/1997 season compared to the previous season ($P<0.05$), the same tendency (NS) being shown in matches. Club A sustained more contusions in the 1995/1996 season ($P<0.01$), the same tendency (NS) being present in both training and match injuries, and a tendency (NS) for a greater number of strain injuries was present in the 1996/1997 season, a consequence of a greater number of strains during training ($P<0.05$).

Injury location was not found to differ between seasons at any club, club B showing a tendency (NS) for a greater proportion of knee injuries during the 1995/1996 season, the same tendency (NS) being present in training injuries. Differences were observed however in training and matches separately; club A sustained a greater relative proportion of thigh injuries during training in the 1996/1997 season ($P<0.05$), while club C received more injuries to the lower leg

during matches in the same season ($P<0.05$).

Differences in injury mechanism between seasons were observed at club A, a greater proportion of injuries taking place while running in the 1996/1997 season ($P<0.05$), the same tendency (NS) being observed for club B for the 1995/1996 season. No differences were observed in the mechanism of match injuries whereas differences in the mechanism of training injuries were observed at club A; both a greater proportion of injuries while shooting and running occurred in 1996/1997 ($P<0.05$), while there were a greater proportion of injuries that took place when turning in the 1995/1996 season ($P<0.01$).

Other parameters considered were the severity of injuries, the proportion of re-injuries, and the timing of competitive match injuries. Club D sustained a greater proportion of minor injuries in 1995/1996 compared to the following year ($P<0.05$), no other differences being observed at any club. The percentage of re-injuries did not vary from one season to the next within clubs. Two clubs displayed differences in the timing of match injuries; in 1995/1996 club A sustained a greater proportion of injuries in the final 15 minutes of matches than in the subsequent season ($P<0.05$), and in 1996/1997 club C sustained a greater proportion of injuries in the middle third of the second half compared to the previous season ($P<0.05$).

Between squads

It was possible to compare the injury profiles of senior players with those of youth players in two of the clubs involved in the study. The injuries sustained by all the senior players involved in the study were also compared against those sustained by youth players. Table 3.13 documents the injury rates for each squad.

Table 3.13: Number and rate of injuries sustained during training and matches for each squad at two clubs.

<i>Club/squad</i>	<i>Number of injuries</i>			<i>Injury rate per 1000 hours</i>		
	<i>Total</i>	<i>Match</i>	<i>Training</i>	<i>Total</i>	<i>Match</i>	<i>Training</i>
A/senior	136	93	43	8.3	32.5	3.2
A/youth	44	26	18	7.0	18.9	2.9
D/senior	127	70	57	7.5	18.6	4.3
D/youth	122	83	39	13.4	53.2	5.2

Based on the ratio of the number of senior and youth players at each club and overall, differences were observed between the two squads in their injury profiles; differences were reported in injury mechanism, nature, location and location of thigh strains. Club D showed a

tendency (NS) for senior players to sustain a greater proportion of injuries through running and shooting, as did Club A with regards to the latter injury mechanism (NS), while a greater proportion of injuries arising out of tackling and collisions were observed in youth players at clubs D and A, respectively ($P<0.05$). Overall, a greater proportion of injuries occurred while running in senior players ($P<0.01$) while collisions and being tackled produced greater proportions of injuries in youth players ($P<0.01$). There was a tendency (NS) at club D for senior players to sustain a greater proportion of strain injuries, while a greater proportion of contusions in youth players was observed there ($P<0.01$), the difference remaining when all senior player injuries were compared with all youth injuries ($P<0.05$). A greater proportion of injuries to the head were observed in youth players at club A ($P<0.01$), which was also the case when all the injuries were compared ($P<0.05$). Both clubs A and D showed a tendency (NS) for senior players to sustain a greater proportion of posterior thigh strains than youth players, which when all the injuries were compared a difference did exist between the 2 sets of players ($P<0.05$); overall there were a greater proportion of anterior thigh strains sustained by youth players ($P<0.05$). Further differences were present between the 2 sets of players as a whole in the proportion of strains to the lower leg, more being present in senior players ($P<0.01$), and the proportion of contusions to the foot, a greater number being observed in the youth players ($P<0.05$); the latter tendency (NS) was shown for contusions to the hip, thigh and ankle.

3.4 Discussion

The definition of injury used in the current study was based on time lost from training and matches, as suggested by several authors⁵⁹⁻⁶¹. The definition follows that used by other authors^{62, 63}, being based on health rather than illness. It included injuries only sustained during regular training or matches that prevented the injured party from participating in normal practice or matches for at least one day, the day of the injury not being included. Following on from this the duration of the absence from participation was documented, allowing a useful assessment of the severity of injury to be made. Four classes of injury severity were defined, the classification system being similar to that used by other authors^{33, 54-56, 58}, thus enabling comparisons to be made between studies. The only alteration was the inclusion of 'slight' injuries (1-3 days) in the current study, therefore allowing calculations to be made concerning those injuries that are reportable under RIDDOR²⁷.

To enable a true injury rate to be calculated exposure needs to be accounted for. For this reason it was only possible to obtain an incidence rate for 90% of the injuries in the study since the remaining 10% of the injuries were sustained at clubs where there was no available data to

enable the determination of the length of exposure. An overall injury rate of 8.5/1000 playing hours was obtained from the current study, which was a result of injury rates of 27.7/1000 hours and 3.5/1000 hours during matches and training, respectively, for individual players. Comparisons between different investigations is difficult owing to the differences in the injury definition used by various authors and the data collection procedures followed. However, results from studies where comparisons may be possible seem to suggest that the injury rates during matches and training are higher and lower, respectively, in English professional football compared to elsewhere, injury rates of 7.6/1000 hours¹⁵ and 7/1000 hours being reported during training⁵⁷ and 11.9-18.5/1000 hours being reported during matches^{15, 55, 56}. To enable judgements to be made on the number of training injuries recorded, details of their contents from different studies would be required. It may be probable that since the current study is one of the few conducted in professional football, a greater number of weekly training sessions are performed at this level, allowing for less intense training to take place compared to where clubs only train 1-3 times per week, which is often the case at semi-professional clubs. Conversely, the highly competitive level at which the games were played by the teams in the current study accounts for the higher injury rate observed, the proposed low intensity training possibly contributing to this higher rate as a result of players not being physically prepared for the competitive matches. To enable a more in depth comparison between studies to be made other factors are in need of consideration; the different seasonal structures employed by football nations could be influential, the number of matches played and the length of time between games, the exhausting match schedules often observed in the English game, all possibly being contributory factors. It should be further stressed that the injury rates reported are only estimates owing to the extrapolation methods used. Ideally, a daily report should be made documenting the number of players training and the length of the sessions, allowing for more precise calculations of exposure to be made. Also, it should be noted that there is most probably an underestimate in the injury rate during training since no account was made for the number of players receiving treatment, who were therefore not exposed to injury; it was assumed that all players were involved in regular training at all times. Further, there is movement of players from club to club throughout the season and therefore the number of players exposed only represents an average.

It has previously been reported that as the level of competition increases there is an increase in the number of match injuries and a decrease in the number of training injuries^{55, 71}. The teams involved in the current study spanned the top three divisions in English professional football. The club involved at the lowest level of competition did have the lowest injury rate in competitive matches, however, comparisons are difficult as data was not available on whether the match injuries were sustained in a 1st, reserve, or youth team match. Because of this it is also difficult to compare injury rates in matches between the senior and youth players. The highest

rate of injuries in training were documented at the club playing at the highest level, although again knowledge concerning the content of the training sessions is required in order to begin to explain the differences in the injury rates observed; the nature of the training sessions employed at most clubs will depend on the individual coaching philosophies that exist there. True exposure calculations would be ideal rather than extrapolating the number of training hours per week across the whole study period.

The incidence of injury has previously been reported to vary over different periods of the playing season^{33, 54, 73, 90}, peak rates being found to occur following pre-season and the mid-season break, and during match intensive periods. The current study lends support to the work of these authors, two main peaks having been identified to occur ($P<0.05$), one after the pre-season training period, which is usually a match intensive period, and the other over the final few months of the playing season, this period again being commonly a match intensive part of the season. Since several studies have reported an increase in injury rate around periods of intense competitive matches, it is important that the number of games played during each period are accounted for. It seems obvious that as two-thirds of the injuries that occur at a football club are *during competitive matches*, the months during which the most matches are played will be found to be the periods during which most injuries are found to occur; it is necessary to consider the *number of competitive match injuries per match per month*. Based on the same number of matches being played during each month, August was reported to be the period during which most competitive match injuries occurred ($P<0.05$), the remaining months of the season showing a fairly consistent injury rate. It is probable that during this period, the first month of the competitive playing season, the players have not yet reached levels of peak fitness and are therefore not in optimal physical and physiological states to be able to withstand the stresses associated with competitive football. Consideration must be given to the contents of pre-season training and also the physiological testing of players to enable more accurate judgements regarding their match preparation to be made. In a study involving professional players from an Italian A league team⁷³ it was reported that their injuries were evenly distributed throughout the season; the fitness levels of the players involved may have been maintained throughout the season making them less susceptible to injury, however this can not be substantiated. It may be thought that the hard ground conditions commonly associated with the early stages of the playing season is a contributory factor, however, no differences were reported in this variable. Also it is worth noting that the winter period, over which matches are often played on hard ground, did not show any increase in injury incidence. The pre-season period appears to be a crucial part of the season since it was also found in the current study that during this period the injury incidence of training injuries was at its peak, the rate gradually decreasing before peaking again slightly during January and February. It should first be acknowledged that the number of

training hours per month was not accounted for in this analysis which could contribute to the pattern observed; the number of hours trained during pre-season are generally greater than at any other time throughout the season and it is possible that during the second peak there are a large number of match cancellations, therefore increasing the number and/or length of training sessions. Future work on this area should therefore consider player exposure during training. Notwithstanding this, it is probable that players return from the close-season period to pre-season possessing lower fitness parameters than they displayed at the completion of the previous season as a result of an absence of, or a poor adherence to, a close-season fitness maintenance programme; however, this is purely conjectural and can not be assessed in the absence of regular player profiling. If this was the case the rapid progression of training programmes usually employed during pre-season would most probably be detrimental to the health and safety of players who have had 4-8 weeks of no or little activity, 14% of the training injuries during this period being overuse. Following on from this and relating back to the previous point, if the players have not been adequately prepared during pre-season, when they then start to play competitive matches it is likely that injuries will occur.

Overall, two-thirds of the injuries were sustained during competitive match play while one-third occurred during regular training. The nature of the injuries sustained were predominantly strains, sprains and contusions which is supportive of previous research^{20, 54-56, 83}, however the percentage of muscular strains reported in the current study dominates the three injury categories whereas ligament sprains have been the most prevalent elsewhere^{86, 158, 159}. Two-thirds of the traumatic injuries occurred during competitive games which is supported by previous work^{56, 58, 73}, however it has also been reported in previous work that one-third of all injuries were classified as overuse, these predominantly occurring during pre-season training^{20, 55-58}. Only 4% of injuries from the current study were of the overuse type, two-thirds of which were reported to take place during matches. These differences could be attributed to the higher competitive level of football played in the current study which has previously been discussed, strains being more prevalent possibly as a consequence of the higher intensity of football played. The lower level of overuse injuries documented and also the difference in the training to match ratio of overuse injuries would again require further knowledge concerning the training content before appropriate explanations could be made. The proposed lower intensity of the training conducted by the clubs in this study and the more infrequent nature of training by clubs in other studies could both be contributory factors. Training pitches and conditions should also be accounted for, a tendency (NS) for the overuse injuries in the current study to occur when training/playing on dry surfaces was observed.

The proportion of different types of injury were different between training and matches, the

percentage of contusions in matches and strains in training both being greater than average ($P<0.01$). The number of contusions sustained in matches is not surprising considering the competitive nature one would expect the games to be played in compared to training, however, the higher proportion of strains observed in training is unexpected. This percentage greatly overshadows the level reported in European research^{56, 58, 73}, and considering the lower levels of intensity already proposed this would not be expected; it is possible that attention paid to general body conditioning in terms of strength and flexibility training, warm-ups and cool-downs are less well adhered to by the players at professional clubs in England compared to European clubs, thus making the players more susceptible to muscular strains. However, more in depth analysis of training practices and techniques would be required to corroborate this.

It has previously been reported that muscular strains represent a greater proportion of injuries in senior players compared to youth players⁶⁸ and that the reverse is true with regards to contusions^{19, 20, 53-57, 69, 83, 84}. The current work confirmed these reports, club D having shown a tendency (NS) for their senior players to sustain a greater proportion of strains than their youth players, and a greater proportion of contusions sustained by their youth players compared to senior players ($P<0.01$), the latter difference being supported from all the data ($P<0.05$). The data also found a greater proportion of strains to the lower-leg and posterior thigh to occur in senior players compared to youth ($P<0.05$), youth players being reported to have sustained a greater proportion of strains to the anterior thigh ($P<0.05$). The injury mechanisms involved in these injuries were running and shooting, these mechanisms being involved in a greater proportion of injuries to senior players than youth players ($P<0.01$). Several authors have reported contusions to the lower leg to be the most common injury in youth players^{53, 67, 70, 76, 84}, contusions to the foot being more common in the youth players involved in the current study compared to the senior players ($P<0.05$), the same tendencies (NS) being observed for contusions to the hip, thigh, and ankle. The injury mechanisms involved in these types of injuries were collisions and being tackled, greater proportions of both mechanisms being responsible for youth injuries compared to injuries to senior players ($P<0.01$). As has been suggested previously by Keller et al.⁶¹, it is believed that contusions may not be tolerated to the same extent in youth players compared to older players; one may expect the reverse to be observed as a consequence of the differences in the intensity of the games in which to two groups of players are involved. The differences in the proportion of muscular strains observed could be attributed to differences between the two groups of players in muscle flexibility, strength and adherence to warm-ups and cool-downs in training and matches, the older players possibly possessing greater muscular strength and lower muscle flexibility. It may be true that few differences exist in the training practices that the groups of players are involved in, however, the natural suppleness that youth players tend to possess would make them less susceptible to muscular strains; if this was the case

the necessity for players to follow thorough flexibility programmes throughout their careers would be crucial for the prevention of this type of injury.

Eighty-seven percent of the injuries in the current study were located in the lower extremity, a level similar to that reported elsewhere^{54, 61}. The most common injury location in the current work was the thigh, followed by the ankle and the knee, the latter two locations having been reported as being the most common injury locations in previous work^{11, 53-58, 72, 76, 83, 87}; however, a tendency has previously been reported in professional and senior football for a greater percentage of injuries to occur to the thigh. The greater number of strains recorded, as has already been discussed, contributes to the higher level of thigh injuries observed since 81% of the thigh injuries were muscular strains. Strains to the anterior and posterior aspects of the thigh have been reported to be common injuries previously^{19, 53-56, 70, 83}, in the current study 64% of the thigh strains were to the posterior aspect rather than the anterior ($P<0.01$). This difference could be attributed to the lack of attention paid to the hamstring muscle group with regards to strength and flexibility training by footballers, strength imbalances between the agonist and antagonist muscle groups often being present⁸⁶. The differences observed between the youth and senior players in the proportion of thigh strains discussed above could be attributed to the dominant quadriceps that are often seen in elite footballers, the same level of strength, and therefore imbalance, not being present in the youth players, thus accounting for the greater anterior thigh strains in youth players and posterior thigh strains in senior players. Evidence is lacking to support this however, data concerning training routines and pre- and post-match activity, together with individual player profiles, being required to enable accurate conclusions to be drawn. A difference between injuries to the posterior and anterior aspect of the thigh with regard to strains did not exist in training, a greater proportion of anterior thigh strains occurring in training compared to matches ($P<0.01$). This is probably a consequence of the greater proportion of injuries arising from shooting during training compared to matches ($P<0.01$), as is discussed below.

Other differences between the location of injuries in training and matches were reported, injuries to the head and foot being more common in matches ($P<0.05$) as would be expected due to the increased competitive nature and intensity of play in matches compared to training. There were a greater relative proportion of back injuries observed in training compared to matches ($P<0.01$) and the same tendency (NS) with regards to lower leg injuries; the former may be connected to the training exercises that are used by clubs, whereas the latter could be attributed to players not wearing shin-pads during training, 86% of the players injured during training having been reported to be not wearing shin-pads at the time of injury. Although contusions and fractures to the lower extremity occurred relatively infrequently during training, shin-pads are designed to

give the player some protection against this type of injury, and therefore it would appear that the chances of reducing such injuries to the lower-leg and ankle would be increased by wearing protective equipment during training, which has been made compulsory during competitive match-play.

Other equipment that was reported to vary depending on whether players were involved in training or a competitive match was the type of footwear. Not surprisingly, studded boots were predominantly worn by players who were injured during matches whereas moulded boots were reported to be the footwear more commonly associated with players injured during training; however, 87% of the players who sustained a knee injury during training were wearing moulded boots, this being greater than the average of 56% reported ($P<0.01$). In American football, the severity and incidence of knee and ankle injuries have been reported to be significantly lower when using shoes with lower friction properties⁹⁵, and prospective research into the football cleat design used by high school American football players showed the design that produced significantly higher torsional resistance was associated with a significantly higher anterior cruciate ligament injury rate than the three other designs studied¹⁶⁰, contradicting the current research that associates moulded boots with a high incidence of knee injuries. Since the demands of football involve sprinting, cutting, pivoting and stopping, the frictional resistance between the shoe-surface interface is required to be within an optimal range. Research into the football shoe has been reported to fall far behind that of running shoes as far as improved function, wearer comfort and foot protection is concerned, no scientific basis existing for locating the studs of a football boot under the ball of the foot, just tradition, with few changes having taken place over the last 30 years¹⁴¹. Future research needs to give consideration to both the performance requirements of the player as well as player safety.

The percentage of lower extremity injuries has been reported to be less in youth players compared to senior players⁶⁷, the same pattern being observed in the current work. A greater proportion of head injuries were observed in the youth players involved in this research compared to the senior players ($P<0.05$), reflecting the higher incidence of head, face, and upper extremity injuries that have previously been documented among youth players^{53, 67, 84}, the greater number of head injuries possibly a consequence of the greater precautions taken by medical staff when a head injury occurs in youth players.

From all the injuries recorded in the current study and also those separately in matches and training, the injured player's dominant side was reported to be the most common site of injury ($P<0.01$). Similar results have previously been documented by Ekstrand and Gillquist⁵⁴ with regards to ankle injuries, it being suggested that the ankle of the dominant leg is exposed to

forced inversion in jumping and kicking movements⁸⁶, and it is most probably the dominant leg that is more commonly involved when tackling or being tackled.

Player to player contact injury mechanisms including tackling, being tackled and collisions accounted for 41% of all the injuries documented in the study. Similar levels have been reported previously⁷³. These injury mechanisms were proportionately greater during matches ($P<0.01$), as would be expected, together with injuries arising from heading ($P<0.05$), however such a high number of injuries occurring where no player to player contact was recorded may seem high. Running, shooting, turning and overuse injury mechanisms were attributable for 45% of the injuries, running, shooting and turning all being proportionately greater mechanisms for injury in training compared to matches ($P<0.01$). Ekstrand and Gillquist⁵⁴ also identified running and turning as being the injury mechanisms during which the majority of the non-contact injuries occurred. The high number of strains, especially during training, in the current study have previously been discussed, and it is these non-contact injury mechanisms that need to be considered in order to lower the levels of injury incidence reported. Other reports have found the majority of muscular strains to have occurred through non-contact injury mechanisms, strains to the rectus femoris on the whole occurring while kicking while those to the hamstrings or gastrocnemius occurred during sprinting⁷³. The results of the current work further imply that the underlying injury aetiological factors previously discussed, i.e. player profiles and training procedures, are in need of assessment.

Further insight into the aetiology of an injury can be obtained by considering the time that has elapsed during a competitive match at the point of injury. The current work found the two 15 minute periods at the end of both halves to display the greatest injury incidence rates, with more injuries occurring during the second half of matches compared to the first ($P<0.01$). Other work has reported the opposite, more injuries occurring in the first half, strains having been identified as being most common during the warm-up and early stages of a game⁵⁴, although the work of Sandelin et al.³³ and Arnason et al.⁸⁸ have shown some similarities to the current research. The role of muscle fatigue has previously been discussed and identified as a factor in injury causation¹²⁵, and it is believed that this can partly explain the greater injury incidence observed in the second half of competitive matches in the current study, especially during the final 15 minutes. If this is the case then the importance that is placed upon a player's fitness is further increased, and also the necessity for appropriate dietary intervention, both aimed at increasing the amount of work a player can perform during a competitive match. Although no differences were reported in the nature, location, or mechanism of injuries with respect to time, 42% of the injuries that occurred while shooting took place in the final fifteen minutes, these injuries being muscular strains. The number of injuries in each category are however few, making any statistical analysis

meaningless, therefore there exists a requirement for a much larger study to enable such statistical comparisons to be made. No analyses were conducted with regards to the timing of training injuries since no account was made on the length of training sessions and whether or not the injury occurred during the first or second session of the day. This could be addressed in future work.

The relevance of players' position to the incidence of injury in competitive matches was found to be significant in the current study. It should first be noted however, that there was an assumed 1:4:4:2 playing system in operation during all competitive matches which may have not been the case. Based on this assumption defenders and forwards were found to be at a higher risk of injury during matches than goalkeepers and midfielders ($P<0.01$), a high injury incidence among defenders having previously been reported ^{20, 68}. A possible explanation for a greater injury incidence among defenders, although this has not always been reported to be the case ^{19, 33, 77, 78}, is the tendency for defenders to take more risks in an effort to defend their goal, general support being shown by the fact that defenders were found to sustain fewer injuries that were the result of a foul ($P<0.05$), defenders themselves either being the perpetrator or being involved in other types of injury incident with regards to refereeing decision, and also defenders being reported to sustain a proportionately greater number of strains compared to other playing positions ($P<0.01$). It is possible that defenders are not tackled as often as other players and are more commonly involved in making tackles themselves since defenders were reported to sustain a greater proportion of injuries through tackling compared to other positions ($P<0.01$), while attackers were injured more often through being tackled ($P<0.01$) which possibly accounts for the greater proportion of contusions sustained by this population of players compared to others ($P<0.01$). It may be useful for future studies to investigate this aspect of different playing positions and also to consider the area of the pitch where an injury occurs and whether the injured player was defending or attacking.

With regards to injuries being the result of a rule offence, 18% of the injuries in the current study were deemed by the referee to be the result of such an offence, several authors having already documented similar levels ^{34, 54, 68}. Ekstrand and Gillquist ⁵⁴ further reported 76% of the injuries that were associated with fouls were caused by the opponent, a figure of 86% being reported in the current study. The current work did not confirm their claims that those players who were injured when committing the fouls sustained more serious injuries than players who were injured when fouled by others, however, it should be remembered that the number of players injured who were in fact the perpetrator are few. It appears then that even though a large proportion of the competitive match injuries involve player to player contact, the number of injuries that are the result of a rule offence are few. A need therefore exists for the injury mechanisms of these

injuries to be considered in detail, possibly requiring minor changes to the laws of the game to be made if common injury mechanisms are identified. Further, the severity of these injuries as well as their frequency should be documented to identify whether changes are in fact required.

The severity of an injury was categorised according to the length of time lost from regular training or matches, which as previously discussed was a natural progression from the definition of injury used in the current study. Only 16% of the injuries were classified as 'slight' in the current study and therefore, under RIDDOR ²⁷, 84% of all the injuries documented were required by law to have been reported to the appropriate authority.

Although it has been stated that comparisons between studies are difficult owing to the differences in definitions used and the different populations studied, the severity of the injuries in the current study are similar to those reported by Ekstrand and Gillquist ⁵⁸ whose study population closest resembles that of the present work, both studies reporting 11% of the injuries to result in an absence from regular training or matches for greater than 4 weeks. The proportion of injuries in terms of severity were reported to differ between those occurring during matches and those during training; a greater relative number of slight injuries were found to take place during a competitive match ($P<0.01$). This pattern is to be expected considering the differences in intensity between training and matches, the latter most probably having a greater number of body contacts, the 'slight' injuries on the whole being contusions and muscle soreness, with injuries to the face and those occurring during heading producing a greater proportion of 'slight' injuries than average ($P<0.05$). No differences in the severity of match injuries were reported between playing positions. Training injuries have previously been reported to be more severe than those sustained during matches in a recent study on professional players ⁸⁹. With regards to the severity of injuries and their removal from the field, differences were observed in training and matches compared to all the injuries ($P<0.01$). In matches it could be expected to observe that of those injuries where the player was immediately removed from the field of play the injuries were more severe than average, however there were still 24 injuries that resulted in at least 4 weeks absence where the player remained on the pitch until the completion of the competitive match. It may be necessary to document future incidents where this happens and whether or not the teams involved have used all their available substitutions. If this is the case the current law on substitutions during competitive matches may have to be re-evaluated, suggestions previously having been made by Jorgensen ⁶⁸. In training, the same tendencies (NS) were observed, although a noticeable difference was the greater percentage of injuries where the player involved was removed from the training pitch either immediately or later. This probably indicates the greater caution that is taken concerning players' health and safety by the coaching staff since there is less at stake during training and therefore, in most cases, players terminate

training as soon as an injury occurs. Consideration should also be given to the injured players themselves; in competitive matches they may be less reluctant to indicate to the coaching staff that they have an injury as it may jeopardise their future place in the team, therefore continuing to play and increasing the severity of what may have been a less severe injury initially.

The total number of days that the players at each club were calculated to be absent from regular training or matches ranged from 504-1651 days, the large difference being a consequence of the number of players involved in the study at each individual club. Calculated as the number of days absence per player per season the number ranged from 21-46 days, i.e. during a typical playing season each club could expect every single player to be unable to train or play competitively for approximately 1 month, or, expressed differently, they could expect 2-5 of their players to be unable to participate in regular playing activities for the whole of the season.

There are few studies in which the total number of days missed have been recorded, the only recent one at the professional level being that by Ribeiro et al.⁸⁹. Over two competitive seasons they documented the number of training days missed due to muscular injuries. The results indicate that there were a greater number of training days missed in the current study but this is probably attributable to the greater number of competitive matches played by professional teams in England compared to Portugal. The researchers also reported the number of days treatment that were required for specific injuries: hamstring injuries (8.9 days) and rectus femoris injuries (13.5 days), however the nature of these injuries were not specified. The mean number of days absent for muscular strains at these two sites in the current work was calculated at 15.7 days and 10.0 days, respectively. It would be wrong to compare these figures, just as it would the differences that exist between clubs in the number of days missed due to specific injuries, since the initial injury may be more severe at one club than at another and therefore a longer rehabilitation period would be required. However, if in future work injuries are classified initially in terms of standard medical classification, namely, degree of inflammation symptoms, i.e. heat, pain, redness, swelling, loss of function and deformity, as well as the number of days missed, the rehabilitation time required for similar injuries can then be compared and the effectiveness of different rehabilitation protocols researched.

The return to activity prematurely and inadequate rehabilitation have previously been reported as being injury risk factors, a high percentage of re-injuries having been found to occur in football. Ekstrand and Gillquist⁵⁸ attributed 17% of the injuries reported in their study to inadequate rehabilitation, and similarly Nielsen and Yde⁵⁵ found 25% of the players who were injured had not completely recovered from a previous injury which was of the same type and location. In the current study it was calculated that re-injuries were accountable for 22% of all the injuries

reported and it is believed that this is an underestimate; only injuries of the same type and location were classed as a re-injury, no assessment was made concerning the effects of some injuries on different body areas. For example, it is possible that a lengthy lay-off from regular training as a consequence of a tibial fracture may lead to muscle weakness in the injured extremity, thus predisposing the muscles and joints of the injured limb, and possibly others, to injury. Imbalances or weaknesses of this kind could be assessed by regular player profiling, a testing procedure which should not only be an integral part of any rehabilitation programme but also as part of the players' general training assessment. Similarly, it was suggested that a right foot contusion could be followed by a left knee sprain as a result of an impairment in timing or neuro-muscular co-ordination⁵⁴. Lysens¹¹³ reported 30% of muscular strains and ligament sprains to be re-injuries of the same type and location, a similar figure of 26% being reported from the current data. Of the re-injuries that were reported in the current research 75% were either strains, predominantly to the lower leg, thigh and groin, or sprains to the ankle and knee, these injuries having previously been reported as having the highest risk of re-injury^{55, 58, 71, 113}. Thirty-two percent of ankle sprains were documented as being re-injuries, Ekstrand and Gillquist⁵⁴ suggesting that this figure could be reduced by more active treatment of acute ankle injuries and the use of prophylactic taping of old lesions. Due to the number of re-injuries that have been reported to occur in football, and the tendency (NS) in the current study for these injuries to be more severe than other injuries, the rehabilitation of players must be considered. It may be that managers are under pressure and are prepared to gamble on the fitness of a player, putting at risk that player's health and safety. There is a necessity for controlled rehabilitation and strict adherence to programmes, the benchmarking of players enabling rehabilitation goals to be set and specific criteria established which must be met before a player is able to return to normal activity. The assessment of rehabilitation protocols in future studies has already been discussed, however they would also enable comparisons between clubs to be made where different re-injury rates are apparent, aiding in the formulation of specific injury rehabilitation protocols.

Strengths and Weaknesses of the Prospective Epidemiological Injury Analysis

The current epidemiological study is the largest and most extensive of its kind ever undertaken in English football at the professional level, and one of the largest world-wide encompassing teams from different levels of play and spanning two to three competitive seasons. The general pattern has illustrated that the injury epidemiology reported in this study does display both similarities and differences to that reported from European studies, but the data also illustrates that even within English football differences do exist between clubs and even within clubs. Although an extensive analysis has been conducted further documentation would enable a more complete analysis. For example, differences in the training activity at the time of injury was reported to differ between clubs, predominant activities being either small-sided games or 11-a-

side practice games. Differences in the injury activity were observed within one club when one season was compared to another, club D sustaining fewer injuries during training ($P<0.05$) but more injuries in matches ($P<0.01$) during the 1996/1997 season compared to the previous season. There were no differences in the number of competitive matches played between the two seasons; however, a new management team was introduced prior to the start of the 1996/1997 season, and subsequent changes in training procedures may have resulted in the observed decrement in training injuries, fewer injuries being sustained during small-sided games. Knowledge of the training procedures implemented during both managerial regimes need to be known, the latter, although having been favourable with regards to training injuries may have been detrimental to the number of injuries players sustained in matches. It should be apparent therefore, that there exists a necessity for every single club, and subcultures within each club, to perform injury analyses both collectively and individually. Comparisons between and within clubs are difficult to make from the available data, and conclusions cannot accurately be drawn without supplementary information regarding individual player characteristics and training procedures, i.e. intrinsic and extrinsic injury factors. The results of the current chapter have established that a substantial number of injuries do occur while the players are participating in regular training activities, therefore it is imperative that the training procedures at clubs are analysed. The results presented in this chapter relating to individual clubs are best discussed following the report on the training analysis (Chapter 4) that was conducted at three of the clubs involved in the study.

CHAPTER 4

AN EXAMINATION OF THE TRAINING PRACTICES CONDUCTED AT THREE PROFESSIONAL FOOTBALL CLUBS

4.1 Introduction

One-third of all the injuries reported by the current work (Chapter 3) occurred during training. Over 50% of these injuries were diagnosed as muscular strains, the majority of which were the consequence of a non-contact mechanism such as running or shooting. The content of training sessions may therefore have an important influence upon these injuries, and also on the injuries that occur during competitive matches. There does appear therefore, a necessity for the practices conducted during regular training to be examined before appropriate recommendations can be made to decrease the risk of injury to players while training and playing matches.

Intrinsic and extrinsic aetiological injury risk factors have previously been described, many potential risk factors having been identified, although epidemiological evidence remains scarce. Intrinsic factors such as flexibility, muscular strength, anaerobic capacity (the total amount of energy that can be obtained from the anaerobic energy systems, exercise using this system being of short duration and not dependent on the availability of oxygen) and aerobic power (the maximum amount of energy that can be produced from the aerobic energy system per unit time ($\dot{V}O_{2max}$)) cannot be established without some form of testing. However, some indication of the extrinsic factors that players are exposed to during matches can be gained by observation, as used in the match analysis discussed earlier. Extrinsic factors of interest in training are the training content itself, the equipment worn by players and their exposure time.

A warm-up can be defined as a group of exercises performed immediately prior to an activity providing the body with a period of adjustment from rest to exercise. It is designed to prepare the individual mentally as well as physically, leading to improved performances¹³², and possibly reducing the chance of injury¹⁶¹. Cool-downs are a group of exercises performed immediately after an activity providing the body with a period of adjustment from exercise to rest. The main objectives of a cool-down are to promote the removal of waste products, reduce muscle soreness, and facilitate muscular relaxation, while it may also at times serve to improve flexibility¹⁶¹.

It is believed that the incidence, intensity or duration of musculotendinous and joint injury may be decreased by the use of stretching exercises as a consequence of increased flexibility^{162, 163}. There does appear to be an ideal range of flexibility that is advantageous in the prevention of muscle strain and/or joint sprain in some sports, however this is not maximum joint flexibility. The question has been addressed of whether there is any benefit of stretching a muscle to an extreme ROM, and it seems that in some sports, such as gymnastics, there is a need to be able to reach an extreme ROM without sustaining any tissue damage; this is not the requirement of all athletes and probably not the case for professional footballers, however sub-optimal ROM values in groups of footballers have been reported⁸⁶.

Following a football match it has been reported the shortened muscle length of certain muscles can take up to two days before the restoration of normal length, while the frequent training and playing of matches, without the implementation of regular stretching, can result in permanent shortening of certain muscles¹⁶⁴. As discussed earlier there are several different stretching techniques commonly used by athletes in all sports. Bangsbo¹⁶⁴ describes a simple and efficient static method of stretching where the subject brings the muscle to a fully stretched position, holding the stretch for 10 seconds before carefully stretching the muscle further and holding for another 10 seconds. He suggests that those muscles that are to be stretched are activated through light activities, ensuring the muscle remains warm throughout the stretching routine, and also that only light stretching is conducted early during a warm-up as the muscles are cold and at a greater risk of injury, a more substantial stretching programme being more appropriate at the end of a warm-up and at the completion of training. Astrand and Rodahl¹³³ suggest contract-relax stretching, a form of proprioceptive neuromuscular facilitation (PNF), to be the most effective stretching technique to improve a joints ROM. They describe the technique to start with a maximal isometric contraction of the muscle group involved for 4 to 6 seconds, relaxation then following for a minimal period of 2 seconds followed by slow, passive, pain free extension of the joint, a maximally extended position being held for 8 to 20 seconds. It is suggested that this sequence should be repeated 5 to 6 times for each muscle group stretched.

As with other sports there is at present a lack of empirical data concerning the optimal flexibility for professional footballers. There also remains a lack of evidence supporting the view that a lack of flexibility predisposes one to injury. Conventional wisdom would though suggest that shortness of muscle and connective tissue limits joint mobility and consequently may predispose that muscle or connective tissue to injury. Therefore, adherence to stretching programmes is advised.

Extrinsic factors previously identified as being of importance are warm-ups, cool-downs, and

their contents ^{64, 104, 107, 137}. The aim of this aspect of the current study was to evaluate as objectively as possible the training content at three professional football clubs, that took part in the injury assessment programme described in Chapter 3, over one full week during the playing season, concentrating upon the warm-up and cool-down procedures.

4.2 Methodology

4.2.1 Data Collection

Three English professional football clubs, who were taking part in the complementary injury assessment project (Chapter 3), each had their regular training activities observed for one full week (Monday to Sunday) between February 1997 and March 1997. Specific training involving players who were being rehabilitated and which was not a part of the main training session was not included. For each club the following factors were documented at every individual training session:

1. the weather conditions;
2. the type and condition of training surfaces;
3. the type of footwear predominantly worn by players;
4. the number of training squads;
5. the number of players taking part in each squad;
6. the duration of the individual squad sessions;
7. whether shin-pads were worn at any time and by how many players; and
8. whether fluids were provided before, during or immediately after the session.

Additionally, for each session involving the first team squad, the following were documented:

1. the duration and content of the warm-up period;
2. the duration and content of the main part of the training session; and
3. the duration and content of the cool-down period.

A standard training analysis sheet was employed for recording all the data from each training session; an example of this is shown in Appendix 3. The results shown indicate that: 1st, reserve and youth team squads all trained, the session being their first of the day, 17, 9 and 14 players being involved in each squad, respectively; each squad session ranged from approximately 1 hour to 100 minutes; no player wore shin-pads; there was no activity prior to formal warm-ups;

the 1st team warmed-up as one group involving specific ball work which lasted 27 minutes, including 2-3 minutes of unstructured stretching half way through the ball work; the main session consisted of solely 9-a-side for a period of 30 minutes; cool-downs were non-existent with only 4 player conducting any post-training stretching work; 4 players performed some extra work; and fluid in the form of a carbohydrate solution was made available to all players, the majority of whom consumed some post-training.

4.2.2 Data Analysis

The clubs studied are identified by the same code letters as that used in Chapter 3. The majority of the analysis is descriptive in nature. Descriptive data illustrates for each club the number of players in each squad, and for each squad the duration of training sessions, the number of sessions conducted and the number of matches played. For individual 1st team squads the duration of different sections of training sessions are documented with subjective assessments being made concerning the content of aspects of training sessions, equipment worn by players, the training surface and condition, and nutritional intake of players during the observation period. Where values are reported they represent the mean ($\pm$ SD).

4.3 Results

The numbers of players who participated in each training session for each squad at the three clubs are shown in Table 4.1, together with the average length of each session and the number of sessions that were performed during one full week.

Table 4.1: Number of players participating in each training session, its duration, and frequency per week for each squad (mean $\pm$ SD).

<i>Club</i>	<i>Squad</i>	<i>Number of players</i>	<i>Duration of session (min)</i>	<i>Sessions per week</i>
A	1 st team	12.7 ($\pm$ 3.4)	75 ($\pm$ 18)	4
	Reserves	10.7 ($\pm$ 3.8)	94 ($\pm$ 8)	5
	Youth	9.0 ($\pm$ 1.0)	93 ($\pm$ 13)	5
B	1 st team/reserves	21.0 ($\pm$ 0.8)	81 ($\pm$ 9)	3
	Youth	10.3 ($\pm$ 5.1)	88 ($\pm$ 8)	4
D	1 st team	14.7 ($\pm$ 2.6)	48 ($\pm$ 11)	5
	Reserves	9.3 ($\pm$ 0.6)	103 ($\pm$ 3)	5
	Youth	13.3 ($\pm$ 0.6)	97 ($\pm$ 6)	5

The 1st team and the youth team at each club played a competitive match over the weekend

covered by the observation period, with the 1st team and the reserve team at each club also playing one competitive match mid-week except the 1st team at club A who did not have a mid-week match (Table 4.2). All squads conducted what appeared to be an regular training session for that club, in terms of intensity and length, the day before a mid-week match, clubs A and D also conducting a light, shorter training session on the morning prior to a mid-week evening match. The reserve and 1st team squads at the latter two clubs, respectively, both performed a training session on the morning after a mid-week match, the 1st team session involving very light work. The day following a Saturday match none of the squads trained while from the 1st team squads, all of whom trained on the morning of the day before a Saturday match, only club A conducted a session which was lower in intensity and shorter in duration than their other sessions observed.

Table 4.2: Distribution of training sessions (✓) conducted by each squad throughout a 1 week period also identifying when competitive matches were played (*).

Day	Club A						Club B						Club D					
	Youth		Reserve		1 st		Youth		Reserve		1 st		Youth		Reserve		1 st	
	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
Mon	✓	-	✓	-	-	-	✓	-	✓	-	✓	-	✓	✓	✓	-	✓	-
Tue	✓	✓	✓	-	✓	✓	✓	-	-	*	-	*	✓	-	✓	-	✓	-
Wed	✓	-	✓	*	-	-	-	-	-	-	-	-	✓	-	✓	*	✓	*
Thu	-	-	✓	-	✓	-	✓	-	✓	-	✓	-	-	-	-	-	✓	-
Fri	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-	✓	-
Sat	*	-	-	-	-	*	*	-	-	-	-	*	*	-	✓	-	-	*
Sun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

On the whole each squad trained separately with only the reserves and 1st team at club B training together with occasions where the youth team was also involved.

All sessions began with a warm-up which consisted of general and/or specific activities, the duration of each type in all 1st team sessions at each club being shown in Tables 4.3a-c. Following the warm-up the main part of the session was carried out with one club regularly ending the training session with a cool-down (Table 4.3a). The mean duration of each training session for the 1st team at each club ranged from 48 (± 11) min to 81 (± 9) min (Table 4.4).

Table 4.3a: Duration (min) of different sections of the 1st team training sessions at club A.

<i>Activity</i>	<i>Mon</i>	<i>Tue</i>		<i>Wed</i>	<i>Thu</i>	<i>Fri</i>	<i>Sat</i>	<i>Sun</i>
		<i>am</i>	<i>pm</i>					
Warm-up -general	-	20	10	-	19	20	-	-
-specific	-	10	10	-	11	-	-	-
Main session	-	32	35	-	60	26	-	-
Cool-down -general	-	23	10	-	6	10	-	-
-specific	-	-	-	-	-	-	-	-

Table 4.3b: Duration (min) of different sections of the 1st team training sessions at club B.

<i>Activity</i>	<i>Mon</i>	<i>Tue</i>	<i>Wed</i>	<i>Thu</i>	<i>Fri</i>	<i>Sat</i>	<i>Sun</i>
Warm-up -general	5	-	-	-	10	-	-
-specific	33	-	-	27	38	-	-
Main session	53	-	-	46	26	-	-
Cool-down -general	-	-	-	5	-	-	-
-specific	-	-	-	-	-	-	-

Table 4.3c: Duration (min) of different sections of the 1st team training sessions at club D.

<i>Activity</i>	<i>Mon</i>	<i>Tue</i>	<i>Wed</i>	<i>Thu</i>	<i>Fri</i>	<i>Sat</i>	<i>Sun</i>
Warm-up -general	13	14	10	7	16	-	-
-specific	-	12	-	-	14	-	-
Main session	30	30	25	35	34	-	-
Cool-down -general	-	-	-	-	-	-	-
-specific	-	-	-	-	-	-	-

Table 4.4: Average duration (min) of different sections of the 1st team training sessions (mean $\pm$ SD).

<i>Club</i>	<i>Warm-up</i>		<i>Main session</i>	<i>Cool-down</i>
	<i>General</i>	<i>Specific</i>		
A	17 ($\pm$ 5)	18 ($\pm$ 5)	38 ($\pm$ 15)	12 ($\pm$ 7)
B	5 ($\pm$ 5)	33 ($\pm$ 6)	41 ($\pm$ 14)	2 ($\pm$ 3)
D	12 ($\pm$ 4)	5 ($\pm$ 7)	31 ($\pm$ 4)	-

The general warm-up consisted of some or all of the following activities: walking, jogging at various velocities (forwards and backwards), skipping (with various forms of upper body movement), side-stepping, heel flicks and high knees. The specific warm-up involved exercises with the ball such as individual ball skills, passing, dribbling and possession drills. The teams stopped at various intervals throughout the warm-up to perform some stretching exercises; the

average number of stretching intervals and the types of stretches performed are indicated in Table 4.5.

Table 4.5: Number of stretching intervals per session, their duration (sec) and the types of stretches performed (mean $\pm$ SD).

<i>Club</i>	<i>Number of intervals</i>	<i>Duration of intervals (seconds)</i>	<i>Type of stretch</i>		
			<i>Ballistic</i>	<i>PNF</i>	<i>Static</i>
A	4.0 ($\pm$ 2.0)	115 ($\pm$ 48)	-	-	✓
B	4.5 ($\pm$ 1.9)	50 ($\pm$ 32)	-	-	✓
D	1.5 ($\pm$ 0.6)	165 ($\pm$ 52)	-	-	✓

Structured stretching sessions were performed at club A, the players at the clubs B and D performing their own stretches most of the time. The types of stretches were generally of a static nature, although where players were told to stretch by themselves some ballistic movements were observed. The length of hold of each stretch ranged from 2-3 seconds up to 15-20 seconds in some cases. The players at club A generally maintained individual stretches for at least 8 seconds, the duration being less at other clubs. The frequency with which different muscle groups and joints were stretched and mobilised, respectively, by the players at each club was difficult to ascertain since players mainly performed their stretches on their own and at random. Generally, when players were asked to stretch by the coach, the muscle groups that appeared to be placed under strain were the quadriceps, hamstrings, adductors, and calf, the latter stretch predominantly being performed with the leg in an extended position. Other areas that were given less attention, if any at all, but were commonly stretched at club A were the back extensors, hip flexors, leg abductors, and the soleus and achilles tendon.

The main part of the training sessions was generally composed of small-sided or 11-a-side games during which frequent bodily contact was observed between players. At club D the small-sided games appeared extremely competitive. Protective equipment in the form of shin-pads was not worn by any of the players observed at any stage during training.

The cool-downs, when performed, generally consisted of 2-3 min of light jogging followed by several stretches. The stretches conducted by the players at each club were similar to those observed in their respective warm-ups, all being static. Stretches were generally held for 10-15 seconds at club A, while at clubs B and D the players were told to 'stretch off' before they left the training pitch which at times resulted in several players stretching their quadriceps, hamstrings or calves for a few seconds, the majority of the players leaving the training field immediately.

The footwear worn by the majority of players appeared to be dependent upon the weather conditions and the type and conditions of the training surface. The week of training at club B was generally performed in wet, muddy conditions, resulting in many players wearing studded boots. The conditions at clubs A and D were mainly dry, consequently most players wore moulded boots. All sessions took place on grass except one session at club D which was conducted on artificial turf, the players in this instance wore running shoes.

Fluid intake by the players was made available at all the clubs either during and after training or just after, never before training. A carbohydrate electrolyte drink (CHO) or water was consumed as indicated in Table 4.6. The number of players consuming fluid and the quantity was not determined.

Table 4.6: Type and availability of fluid intake during training.

<i>Club</i>	<i>Fluid</i>		<i>Training</i>		
	<i>CHO</i>	<i>Water</i>	<i>Before</i>	<i>During</i>	<i>After</i>
A	✓	×	×	✓	✓
B	×	✓	×	×	✓
D	✓	×	×	✓	✓

Post-training, clubs A and D provided food for players which predominantly contained a high carbohydrate content such as bread, pasta, potatoes and bananas, the majority of players being observed to consume some food before departing from the training ground; some players did leave without any dietary intake. No dietary analysis was undertaken at any club.

Consistency of approach to training (e.g. content and duration) varied at the clubs. This often arose through a change in the coach taking the session, occurring at times when several 1st team players did not train and the squad was composed mainly of reserves. At club D the players themselves on occasions took the warm-up. Activities prior to the formal warm-up were observed at all clubs involved in the study, this sometimes being in the form of light skills practices and at other times involved long passing and shooting. Post-training activities were also conducted by a few players, usually involving passing, shooting and sprint work, following which no cool-down or stretching activities were performed. No team strength training sessions were observed, only individuals on occasions being seen to conduct any strength work. These players were mainly from the youth team, the sessions themselves not being observed.

4.4 Discussion

Several areas of concern with regards to the training procedures employed at professional football clubs have been highlighted; namely, warm-up and cool-down procedures and carbohydrate intake, these possibly proving to play an influential underlying role in the injury epidemiology reported at clubs. Hamstring injuries have already been identified as a common injury location (Chapter 3), aetiological factors such as insufficient warm-up, hamstring tightness, muscle fatigue and muscular strength imbalances have been proposed to precede the injury¹²⁷.

Warm-up activities should be specific to the muscle groups that are to be used in the main training session and also those which are subject to greater risk; however, it is probable that accurate data concerning those muscles which are at the greatest risk of injury is unavailable to the majority of coaching staff. The warm-ups in the current analysis consisted of general and football specific activities with varying amounts of stretching being conducted throughout. The activities themselves did tend to progress from a relatively sedate nature into more intense and rapid movements, however this is purely subjective and without any player monitoring, for example of players' heart rates via short range telemetry techniques, it is not possible to make informed judgements.

There is a need to differentiate between flexibility work performed as part of a flexibility training programme and that which forms part of a warm-up/cool-down procedure. Both form part of a planned, deliberate and regular programme of exercises, however the former can permanently and progressively increase the useable ROM of a joint over a time period, whereas the latter is conducted immediately before and after an activity to improve performance and reduce the risk of injury during that activity. Consequently, the type of work performed in a warm-up/cool-down procedure alone will not improve flexibility during subsequent weeks of activity¹⁶³.

Flexibility training programmes are purported to benefit athletes in many ways, psychologically as well as physiologically. An important benefit is the promotion of relaxation, decreasing the level of muscular tension. High muscular tension can lead to decreased sensory awareness, increased blood pressure, energy wastage, decreased circulation and consequently an accumulation of toxic waste in the cells, predisposing the body to fatigue, aches and sometimes pain¹⁶⁵. Only club A was reported to conduct a flexibility session, this being of 15 min duration at the completion of a training session, the content however was unknown as it was conducted inside behind closed doors. Since the stretching that is conducted during warm-ups and cool-

downs is reported not to improve flexibility¹⁶³ but rather aid in the prevention of injuries in the immediate sessions or matches that follow, flexibility training programmes themselves are of increased importance due to the proposed relationship between deficits in flexibility and an increased injury incidence¹⁰⁴⁻¹⁰⁸.

Stretching plays an important role in the reduction of muscular soreness, which may occur immediately after muscular exercise, possibly persisting for several hours, or it could well be delayed and localised not appearing for 24 to 48 hours after the completion of exercise. The latter is commonly referred to as *delayed onset of muscular soreness (DOMS)*. Although the theoretical reasons are not fully understood, slow stretching has been shown to reduce both types of pain. Agility, co-ordination, flexibility, and muscular strength can all be enhanced depending on the stretching methods and techniques employed¹⁶⁶. It should be realised therefore that stretching during the warm-up is not only important due to the ability of the musculotendinous unit to absorb energy being directly related to the muscle temperature and muscle length, but also due to the necessity to assist the muscles of the body to recover from previous sessions, the latter being aided by the use of stretching exercise in the cool-down period at the completion of training sessions or competitive matches. The stretches that were observed in the current study were extremely limited at two of the professional clubs, major muscle groups being neglected and the duration of the stretch generally being inadequate. Even where it appeared that stretches were being conducted it was still unknown whether or not stretches were actually being executed properly and that they were being held at an appropriate point of stretch. Each stretch was generally only conducted once but players at club A performed two repetitions on occasions. This is inadequate since repeated stretches of the same muscle are known to diminish muscle resistance to stretching¹⁶⁷, therefore requiring a greater force and degree of lengthening to tear a muscle. Stretches that were contraindicated in nature were also observed at all clubs, three stretches being commonly observed: the plough, which places unnecessary stress upon the cervical spine; the hurdler-stretch, which places stress upon the medial collateral ligament and medial meniscus of the knee; and a ballistic hamstring stretch where in the standing position one leg is placed across the other and the trunk is flexed, the subject taking his hands to the floor or as close as possible before rebounding to a near upright position and repeating the movement, this movement placing a considerable amount of stress upon the lumbar spine. Other stretches can be just as effective in stretching the desired muscle groups and are far safer; Sullivan et al.¹⁶⁸ found hamstring stretching in an anterior pelvic tilt to be more effective than in the posterior pelvic tilt, also, through stretching the hamstrings with the leg outwardly or inwardly rotated at the hip would place a greater stretch upon the semitendinosus and semimembranosus, and the biceps femoris muscles, respectively, these techniques not being observed. Without coach and player education different techniques will not be realised and the health and safety of

professional footballers may be put at unnecessary risk.

Two basic types of flexibility exist: static, which relates to the ROM about a joint with no regard to speed, and dynamic, which represents the ability of a joints ROM in the performance of a physical activity at normal or rapid speed ¹⁶³. None of the players were assessed for either type of flexibility, however, it is thought that deficiencies in dynamic flexibility in professional footballers would be detrimental to their health and safety. Because of the movements that are carried out in competitive football and their ballistic nature the author feels that there is a place for ballistic stretches in the latter stages of a warm-up procedure despite the reported dangers of this type of stretch; the majority of flexibility techniques observed in the current study were static, the few ballistic stretches that were performed being contraindicated. PNF techniques were not observed at any club, although numerous researchers have found PNF techniques to produce the largest gains in ROM ^{169, 170}, with other benefits including greater strength, balance of strength, stability about a joint, enhanced endurance, blood circulation, co-ordination, and relaxation of the muscles ¹⁶⁹. As with other techniques arguments and controversy against PNF techniques do exist, some methods being uncomfortable and painful ¹⁷⁰, and since PNF involves more muscle tension their procedures need to be closely monitored so that any chance of injury is minimised. However, through appropriate education the risk of injury can be reduced and these different stretching techniques will provide variety for both the players and coaches that may lead to a greater amount of flexibility work being conducted and subsequently a reduced risk of injury to players.

The utilisation of cool-downs was neglected at two of the three clubs observed; club A being the only club to cool-down on a regular basis. The stretching that formed part of any cool-down procedure was similar to that observed as part of the warm-up at each club and therefore the same limitations exist. It appears that the value of cool-downs following the completion of a training session is not appreciated, the players' health and safety in both the short and long term being compromised; in the short term a cool-down and stretching at the end of a session will assist the body in recovering for the following training session, whereas in the long term stretching and flexibility work conducted post training will increase ROM and decrease the risk of injury. Moller et al. ¹⁷¹ reported ROM to be increased in 3 of 6 measurements 24 hours following a training session which involved the implementation of stretching exercises both before and after the main session, compared to an increase in ROM in 1 of 6 measurements where stretching was only conducted prior to training and a decrease in ROM in all 6 measurements 24 hours following regular training. Both coaches and players need to be educated in the importance and benefits of such training procedures, not only pre- and post-training but also pre- and post-matches where the same principles apply.

The benefits of strength and strength training for footballers in terms of performance enhancement and injury prevention have been previously reported ^{83, 172-175}, improvements being reported in leg strength, kicking power, sprint times and vertical jump performance. No team strength training sessions were conducted at any of the clubs during each week of training that was observed; a minimal number players did perform individual strength sessions, however the regularity and contents were not documented. There are many misconceptions that exist with regards to the relationship between strength training and flexibility which could account for the reported observations. Stated simply, if strength training is conducted properly, flexibility does not decrease but can actually be increased ¹⁷⁶, therefore both strength and flexibility can be improved together. Two important principles to follow when developing flexibility in this way is that the entire muscle or muscle group must be worked through its full ROM, and that there is a gradual emphasis on eccentric muscular contraction; it should be remembered that this type of training is associated with muscular soreness which can be reduced through specific stretching techniques. Overall conditioning has been reported to result in muscle hypertrophy accompanied by increased vascularity with enhanced circulation and supply of nutrients and consequently less fatiguability ¹²⁷, further minimising the risk of injury. Via appropriate player and coach education these misconceptions could be rectified, subsequently leading to changes in the training routines commonly observed at professional football clubs and ultimately a decrease in the risk of injury to players.

The role of fatigue as a proposed injury aetiological factor has previously been discussed, and the effect of dietary intervention in delaying the onset of fatigue cannot be over estimated. It was observed that at two of the clubs players generally ate following training although this was not mandatory. It does appear that good dietary habits are being implemented, however no dietary analysis was undertaken and therefore accurate judgements cannot be made. The author does still suggest though that despite the reported observations and the supposed good dietary interventions being made at clubs, the full impact which an appropriate diet can have on the professional footballer in terms of his performance and in the prevention of injury, is not fully appreciated. This is further discussed in a subsequent chapter.

It has been well documented that dehydration of as little as 2% of body mass significantly impairs performance ¹⁷⁷. Hypohydration can be detrimental to the professional footballer since endurance capacity and thermoregulation can be impaired, gastric emptying impaired and the risk of gastrointestinal upset increased ¹⁷⁸. There is also the consideration of the impairment of cognitive function, performance decrements being associated with body fluid deficits of 2% and above ¹⁷⁹, this level of dehydration having been observed in games players playing under

competition conditions¹⁸⁰. Although the amount of fluid consumed by individual players was not monitored in the current analysis it was observed that clubs A and D had fluid available both during and after training sessions while club B only provided their players with fluid after sessions, the fluids either being in the form of water or a carbohydrate electrolyte drink, the concentration of which was unknown. It has previously been reported that during continuous moderate-intensity exercise athletes fail to replace their sweat losses fully, replacing only about 50%^{181, 182}. It has been reported in football players that even though they were able to drink *ad libitum* throughout training only 42-48% of sweat losses were replaced, similar to the 35-54% replaced during matches when fluid was available only during the warm-up and half-time¹⁸³. It appears that it is not solely game regulations that limit fluid intake. There is a requirement for strategies aiming to maximise fluid intake that will help coaches and players realise the importance of optimal hydration in performance and injury prevention. Adaptation should be made accordingly for each individual since some will be more prone to sweat loss than others, thus requiring more fluid intake. Adequate fluid replacement is essential if dehydration and its resultant impact on both health and performance are to be minimised.

The weekly training pattern was found to vary between the three clubs mainly as a consequence of the different match schedules of the teams at each club, not only during the week observed but also the match schedules during previous and future weeks. Prior to the weeks observation at club A the 1st team had just ended an extensive cup run, being engaged in a large number of games over a relatively short period; this together with the stage of the season is suggested to strongly influence the training patterns observed. The 1st team at club D did conduct a light training session the morning following an evening competitive match, however, it is not possible to compare the importance and influence of such a recovery session on the players to those involved in teams who do not conduct such a session since there is no documentation on the duration and content of any cool-down procedures conducted immediately after competitive matches, which may be extensive and commonly implemented at other clubs.

Differences in the training practices conducted at the clubs observed have been identified, and also that differences do exist within clubs depending upon the coaching staff conducting the training session. Table 4.7 summarises the strengths and weaknesses and the differences between the 1st team sessions at the three clubs observed in terms of warm-ups, cool-downs, strength and flexibility training and fluid and carbohydrate intake. It should be noted that no assessment of the components of specific aerobic and anaerobic training was undertaken, an area of work that needs to be addressed. Table 4.7 simply summarises, subjectively, the adequacy of specific components in terms of content and length, assessed against suggested practices that should be employed within football¹⁶⁴.

Table 4.7: Summary of a subjective evaluation of adequacy (poor, adequate, good, excellent) of specific 1st team training components at individual clubs.

<i>Training components</i>	<i>Club A</i>	<i>Club B</i>	<i>Club D</i>
<i>Warm-up</i>			
general/specific (length and progression)	excellent	adequate	adequate
<i>Stretching</i>			
lower extremity (adductors, hamstrings, quadriceps, iliopsoas, calves)	good	poor	poor
length/repetitions	adequate	poor	poor
progression	adequate	poor	poor
<i>Cool-down</i>			
general/specific	good	poor	poor
<i>Stretching</i>			
lower extremity (adductors, hamstrings, quadriceps, iliopsoas, calves)	good	poor	poor
length/repetitions	adequate	poor	poor
<i>Flexibility training</i>	adequate	poor	poor
<i>Strength training</i>			
basic	poor	poor	poor
functional	poor	poor	poor
<i>Fluid</i>			
before training	poor	poor	poor
during training	adequate	poor	adequate
after training	good	good	good
<i>Carbohydrate (solid)</i>			
after training	adequate	poor	adequate

It can be seen that most aspects of the training components considered can be improved upon at all clubs, especially at clubs B and D where only a few components were assessed as being at least adequate, the remainder being poor. Simple changes could easily be made to current training routines and additional practices integrated into training programmes as a whole, aiming to minimise the risk of injury to players by utilising known sports science initiatives. Reasons for the different approaches observed need to be addressed, assisting in the identification of what injury prevention strategies are required, where and who they should be aimed at and how they should be implemented.

Strengths and Weaknesses of the Examination of Training Practices

The current analysis is limited and descriptive in nature. The study period for each club was only one week, therefore any differences between the training sessions over different stages of the season could not be identified, and only one squad could be observed since they tended to train separately, thus not allowing for any comparisons between the training practices utilised by different squads within the same club. It was noticeable that whoever led the training sessions within a particular club the structure and quality of the training sessions appeared to vary, further highlighting the necessity for all squad training sessions to be observed in future work. Other limitations exist such as the failure to be able to recognise, if any, changes in the weekly training pattern; any progression that is inherent in the training sessions is not seen over a one week period, therefore persistent high intensity training without alternate easy days, sudden mileage increases or increases in intensity with no adaptation time would not be detected, all of which are training errors associated with overuse injuries¹⁸⁴. Although the training conducted at each club was only observed for one week, the observations do highlight some areas worthy of further consideration. All the players observed, bar the youth squad at club B, were involved in the injury analysis previously documented, and therefore the current analysis and its relationship to the injuries reported at each club assists in ascertaining the aetiology of injury, this being required before any prophylactic measures can be proposed and implemented. Further, as well as documenting the injuries sustained at each club it would be worth identifying the awareness and beliefs of the players with regards to injury prevention strategies, with the aim of assessing why certain training/injury prevention procedures observed were or were not implemented. This would aid the identification of those areas where injury prevention strategies should be implemented. From the exposure values reported in the current work, it appears that the availability of time for the players is not a factor, however careful planning is required to enable a schedule of flexibility, strength, plyometric and sprint training programmes to be integrated into current training regimes, making them practicable but also sensitive to the training status and playing demands of the players.

CHAPTER 5

ASSESSMENT OF PROFESSIONAL FOOTBALLERS' AWARENESS OF INJURY PREVENTION STRATEGIES

5.1 Introduction

The health benefits of exercise and sport are well known and have been comprehensively documented ¹; however, the risk of a player sustaining an injury during exercise is always present. Epidemiological studies from several countries imply that the risk of injury from sport is significant ³⁻⁵, the current research (Chapters 2 and 3) confirming this, indicating the necessity for preventive action. Since football is the most popular game in the world, in the USA football being the fastest growing team sport ^{19, 67, 185}, it is not surprising that football injuries have become of increased medical interest. In order to prevent these injuries knowledge of the aetiological factors that influence injury are necessary.

Although there have been advances in medical expertise and technology, knowledge concerning the aetiology of football injuries remains limited. Aetiological factors related to football injuries can be divided into intrinsic and extrinsic groups; however, injuries are often the result of an accumulation of these variables, thus their prevention is complex. Epidemiological studies have focused on both these areas; whilst Ekstrand and Gillquist ^{54, 58} and Zariczny ¹⁸⁶ suggested that intrinsic factors are responsible for the majority of sports injuries, Lorentzon ⁹⁴ stated that the area of intrinsic risk factors was highly conjectural with many plausible hypotheses at present lacking substantiating evidence.

UK health and safety legislation aims to protect people from injury at work and, professional sportspeople, as employees, are also covered by this legislation ²³. Important aspects of this legislation are the requirements under Regulations 8 and 11 of the MHSW Regulations ²⁶ for employers to ensure that their employees have been provided with adequate information and training regarding the hazards and risks to their health and safety. The way in which this information is perceived by footballers will depend upon their beliefs, which in turn affect their behaviour. Beliefs are subject to change and are developed by many stimuli, including individual experiences and social interactions. Players' responses to perceived risks will be influenced by

their perceptions, experiences, attitudes, personality or even their footballing ability. A player who has sustained an injury that may have been career threatening may now perceive injury prevention procedures as being an integral aspect of his training. Personal experience is widely believed to have a powerful impact on the recognition of risk and willingness to take precautions¹⁸⁷. The beliefs a player holds influence the way he thinks, feels and behaves in relation to certain situations. The decisions players make concerning specific training procedures, accidents or incidents experienced or observed will be influenced by their attitudes, as will the managerial/coaching staff commitment to specific practices. If this information is perceived as being consistent with their existing attitude then it will be more readily accepted and implemented. Within football, the aim of this information and training should be to ensure that players, coaches and managers are aware of current sports science and medical knowledge and that this information is converted into safe playing and coaching procedures.

The learning and implementation of new procedures takes time, old routines needing to be surpassed. Over time specific routines are learnt, attention being required in the early stages before gradually becoming automatic, routines once being initiated running through to their completion without the requirement of conscious control. It is felt that few changes have taken place in professional football over recent decades with regards to player practices aimed at reducing injuries even though vast sports science advances have been made; based on the literature it is believed that sports science initiatives, such as advances in flexibility training¹⁶⁶, strength training¹⁸⁸ and rehabilitation techniques¹⁸⁹, can positively influence professional footballers' health and safety. There may exist a requirement for old behavioural routines to be overridden with those based on sports science research, however this process will demand attention and a conscious effort from all involved before they are accepted and implemented automatically.

Strategies for injury prevention in football can be pitched at several levels¹⁹⁰. Primary prevention strategies include, for example, graded preparatory activity through appropriate warm-ups and cool-downs, nutrition advice, flexibility and strength training and the use of protective equipment. Secondary prevention strategies include coach and athlete education, addressing the importance of the above primary preventive measures. The current Chapter focuses on identifying players' knowledge, awareness and application of injury prevention strategies within English professional football. This will enable areas of weakness regarding the professional footballers' health and safety to be identified, allowing for appropriate suggestions of where injury prevention strategies should be implemented, thus ensuring that professional football clubs are in compliance with UK health and safety legislation, supplementing the probable financial benefits and moral obligations.

5.2 Methodology

5.2.1 Questionnaire Design

The questionnaire was initially piloted prior to being administered as part of the main study. Six people who had previously completed or were currently playing football at a professional level completed the questionnaire. Feedback was given on the wording, understanding and layout of the questionnaire; no changes were deemed necessary.

The questionnaire, containing 52 items, was divided into four sections (Appendix 4): Part A provided demographic information on the footballer's age, number of years as a professional, playing position, current league, and the number of injuries sustained, in training and competitive matches, over the previous twelve month period. Part B addressed current injury prevention practices, for example, the use of shin-pads, carbohydrate consumption, warm-ups, cool-downs, and flexibility and strength training with answers represented on a 5-point scale. Part C concerned player's perception of injury risk with answers represented on a 5-point scale. Part D questioned the advice which players received and the reasons, if applicable, for why good practice relating to issues addressed in Part B were or were not followed.

5.2.2 Questionnaire Administration

Players from five English professional football clubs took part in the questionnaire survey. Four of the clubs were involved in the complementary injury assessment project (Chapter 3), three of these also being involved in the analysis of training (Chapter 4). The questionnaire was thoroughly discussed with club physiotherapists who subsequently distributed copies to their professional playing staff. After the initial discussion up to two reminders were sent to club physiotherapists for the return of completed questionnaires. The survey took place between April 1996 and February 1997.

5.2.3 Questionnaire Analysis

The clubs are identified by the same code letters previously used. Completed questionnaires were coded and transcribed onto a computer database for analysis. All data were processed using the software SPSS. In performing statistical analyses Student's t-test for correlated means was used to investigate differences between the following variables: the number of match and training injuries; the number of individual and team flexibility sessions; and the number of individual and team strength sessions. The chi-square significance test was used to investigate differences between the following variables: players' beliefs of the likelihood of injury in

training and matches; carbohydrate consumption and nutritional advice pre- and post- matches and training; implementation of warm-ups and cool-downs (pre- and post-, respectively, training and matches); perceptions of the benefits of conducting warm-ups and cool-downs (pre- and post-, respectively, training and matches); and stretching during warm-ups and cool-downs (pre- and post-, respectively, training and matches). Statistical significance was accepted at the $P < 0.05$ level. Values are reported as a mean ($\pm$ SD).

5.3 Results

5.3.1 Response Rate

Fifty-five respondents, from the five clubs, participated in the study, representing a mean response rate of 38% to the questionnaire from the clubs (Table 5.1).

Table 5.1: Questionnaire response rate from five clubs (mean $\pm$ SD).

<i>Club</i>	<i>Number of players</i>	<i>Number of respondents</i>	<i>Percentage response</i>
A	28	6	21.4
B	24	9	37.5
C	26	9	34.6
D	44	16	36.4
E	25	15	60.0
<i>Total</i>	147	55	38.0 ($\pm$ 13.9)

5.3.2 Player Characteristics

The mean age and number of years played in professional football of the respondents were 25 ($\pm$ 4) years (range 18 to 38 years) and 6 ($\pm$ 4) years (range 1 to 16 years), respectively. The players responding played in the English Premier (16%), Division One (40%) and Division Two (44%) leagues and their playing positions were as forwards (20%), midfielders (44%), defenders (26%) and goalkeepers (10%).

5.3.3 Risk of Injury in Training and Competition

There was no difference overall between the number of competitive match injuries and training injuries reported by each player for the previous 12 months (1.3 ± 1.3 vs 0.9 ± 1.1 , respectively, NS). However the responses from players at one club revealed that there had been more

competitive match injuries than training injuries (1.3 ± 1.3 vs 0.3 ± 0.5 , respectively, $n=15$, $P<0.05$). Whilst 82% of players agreed or strongly agreed that they were likely to obtain an injury in a competitive match that prevented them from playing, fewer expressed the same opinion with respect to training (60%, $P<0.01$). However, only 9% believed that the chance of sustaining an injury in training was greater than during a competitive match with 7% not expressing an opinion. Forty-five percent of players felt that there was a greater chance of an injury towards the end of a competitive match than at any other time, although 16% did not agree. Players were equally split in their belief of whether injuries were or were not the result of actions of other players.

5.3.4 Protective Equipment

In competitive matches shin-pads with ankle protection were always worn by 51% of the players; however 42% never wore shin-pads with ankle protection. Ninety-three percent of the respondents revealed that they never wore shin-pads in training while only one player said that he always did. Fifty-four percent of the players agreed that the risk of lower leg injuries is reduced by wearing shin-pads, even though 97% of these players said that they never wore them during training. Ninety-six percent of the players said that they were not encouraged to wear shin-pads during training, with no players agreeing with the statement that the majority of players wore shin-pads.

5.3.5 Nutrition

Figure 5.1 shows the players' responses to whether they consciously consumed carbohydrates in certain situations. Seventy-eight percent of the players replied that they always consumed carbohydrates prior to a match, whilst only 26% replied that they always consumed them prior to training. Twenty percent of players replied that they always consumed carbohydrates post-match whilst 29% always consumed them post-training. Responses indicated that carbohydrates are consumed more often after training than either prior to training or after a match ($P<0.01$ and $P<0.05$, respectively), although there was no difference in the regularity of consumption between the pre-training and post-match situations.

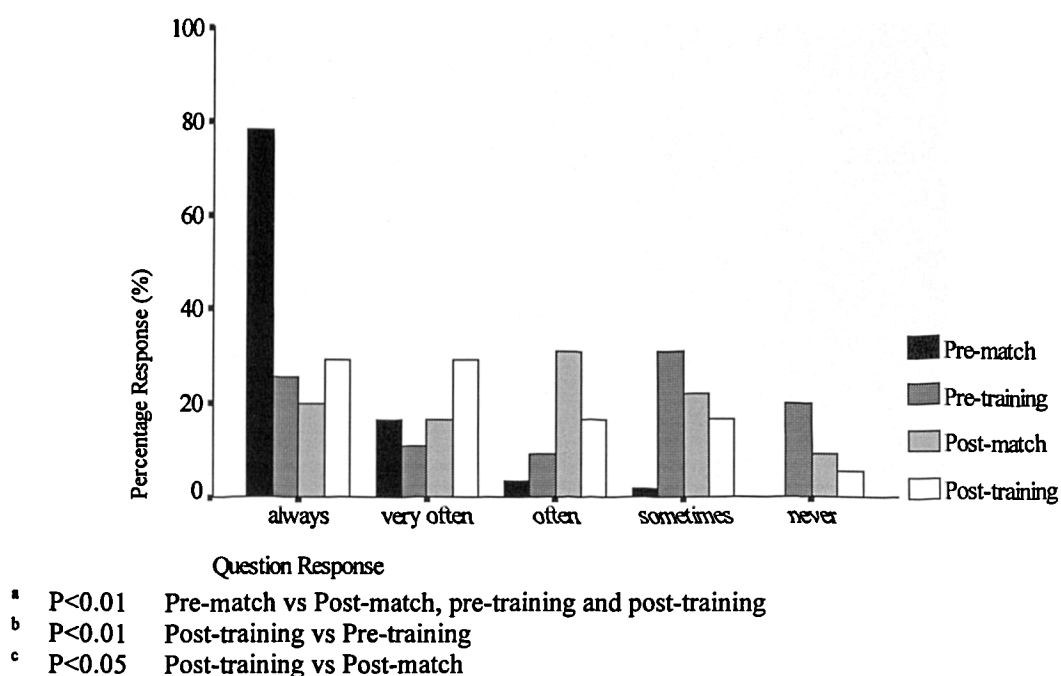


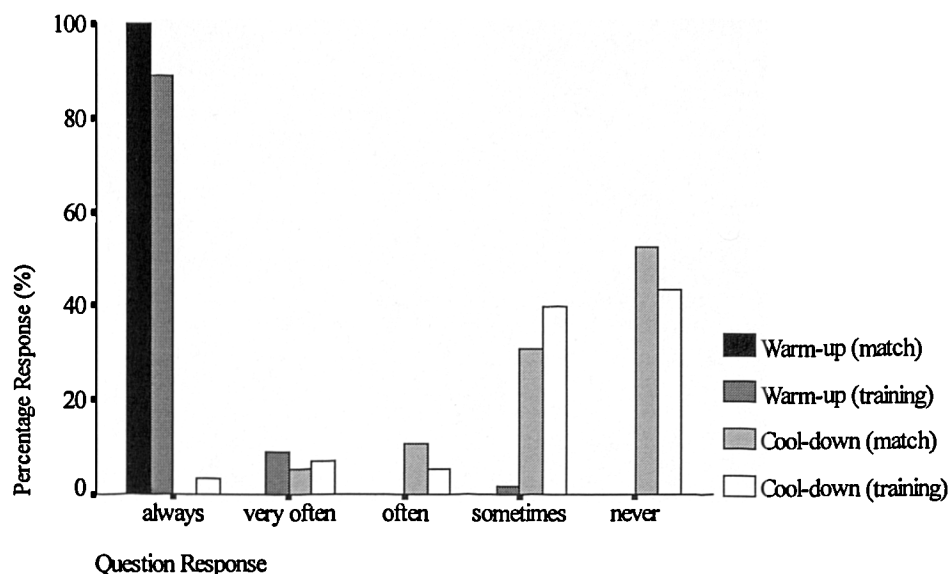
Figure 5.1: Carbohydrate consumption pre- and post- training sessions and competitive matches.

The amount of nutritional advice the players were given regarding carbohydrate consumption in the above situations was found to be similar. Players said that they were given some advice prior to (87%) and post (73%) competitive matches, and prior to (73%) and post (76%) training.

5.3.6 Training

Warm-ups and cool-downs

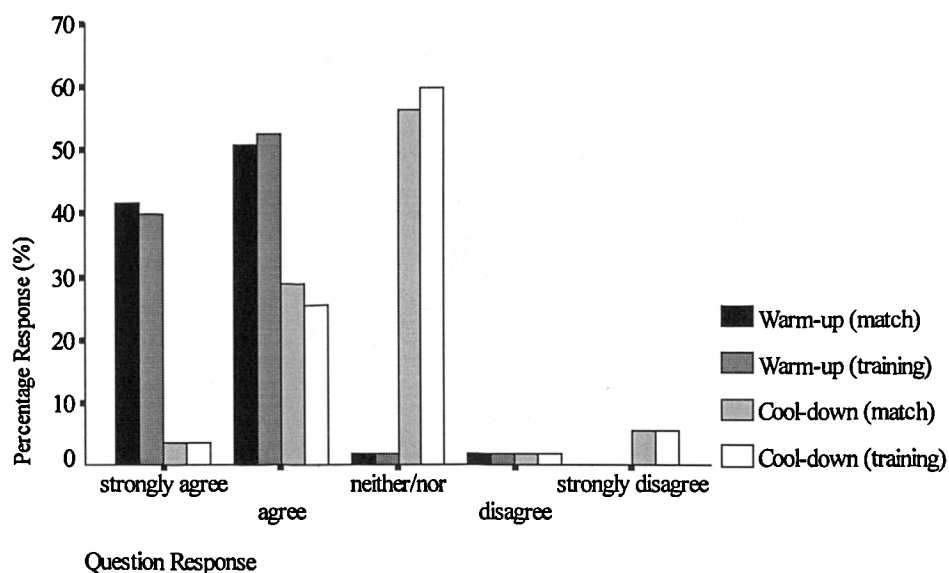
Figure 5.2 shows the responses to questions on the regularity with which players warm-up and cool-down before and after training and matches. One hundred percent of the players always warmed-up prior to matches and 89% always warmed-up prior to training. No player said that he always cooled-down after matches and only 4% of players said that they always cooled-down after training. Forty-four percent and 53% of players said that they never cooled-down after training and matches, respectively. There was no difference between the regularity with which players warmed-up pre- training and matches, as was the case with cool-downs post- training and matches, however players warmed-up on a far greater regularity prior to both training and matches than they cooled-down after the two situations ($P<0.01$).



^a $P < 0.01$ Warm-up (match/training) vs Cool-down (match) and cool-down (training)

Figure 5.2: Warm-ups and cool-downs pre- and post- training sessions and competitive matches.

Figure 5.3 shows the players' perceptions of the benefits of a warm-up and a cool-down with respect to the risk of injury. Ninety-six percent of players agreed or strongly agreed with the statement that the risk of injury is reduced by a thorough warm-up, including stretching, prior to training and matches; however only 33% and 36% of players agreed with the benefits of a cool-down and stretching after training and matches, respectively. The benefits with respect to the reduction in the risk of injury, of a warm-up, prior to both training and matches were seen to be greater than a cool-down after training and matches ($P < 0.01$).



^a $P < 0.01$ Warm-up (match/training) vs Cool-down (match) and cool-down (training)

Figure 5.3: Players' perceptions of the reduction in injury risk by warm-ups and cool-downs.

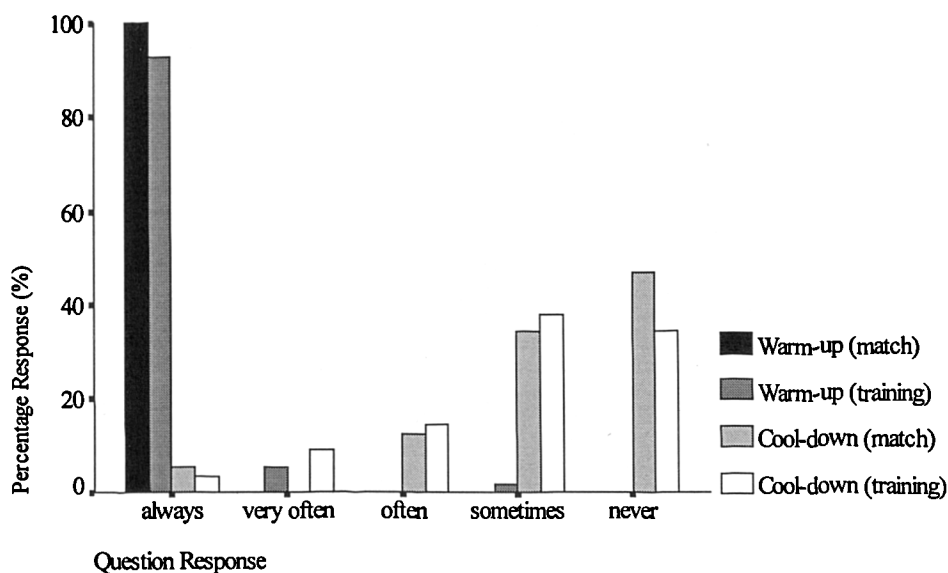
Seventy percent of players gave reasons for not always conducting a cool-down after training or matches (Table 5.2). The most dominant response in each case was that players were 'not told to cool-down', followed by 'nobody else does it' and that they were 'too tired after training/matches'. Only 3% of the players in both situations said that there was 'not enough time'.

Table 5.2: Responses given by players for why cool-downs are not always performed post- training and competitive matches.

	<i>No time</i>	<i>Too tired</i>	<i>Not told to</i>	<i>No advice</i>	<i>Not necessary</i>	<i>Nobody else does it</i>
Training	3%	34%	63%	8%	32%	45%
Match	3%	37%	55%	11%	29%	45%

Flexibility

Figure 5.4 shows the regularity with which players said they stretched the major leg muscles as part of a warm-up pre- or a cool-down post- training and matches. One hundred percent of players always stretched prior to a match and 93% always stretched prior to training. Only six percent of players always stretched after matches and 4% always stretched after training, with 35% and 47% of players never stretching after training and matches, respectively. Players stretched the major leg muscles on a far more regular basis prior to both training and matches compared to after them ($P<0.01$).



^a $P<0.01$ Warm-up (match/training) vs Cool-down (match) and cool-down (training)

Figure 5.4: Flexibility work on the major leg muscles during warm-ups and cool-downs pre- and post-training and competitive matches.

Flexibility work that did not form part of a warm-up or cool-down was also reported by the players. Seventy-three percent of players said they did not take part in any weekly team flexibility sessions and 66% said they did not perform individual flexibility work. Fifty-three percent of the players did not perform any flexibility sessions. The number of weekly flexibility sessions performed on an individual basis was greater than that performed as a team session (0.7 ± 1.2 vs 0.3 ± 0.5 sessions per week, respectively, $P < 0.01$). Eighty-three percent of the players, who did not perform at least one flexibility session per week, gave responses to explain why. Reasons given were: they were 'not told to do it' (48%), they were 'not given any advice on techniques' (44%), 'nobody else did it' (32%), they 'did not believe it was necessary' (20%), they were 'too tired' (8%); no players responded that there was 'not enough time'.

The perceptions the players had with respect to flexibility and the risk of injury was that 47% agreed that players with poor flexibility are more likely to get injured than those with good flexibility, however 20% expressed some degree of disagreement.

Strength

Strength training as part of a team session and as extra individual work was reported by the players. Twenty-four percent of players said they did not perform any weekly team strength sessions and 15% gave the same response for individual strength work. Sixty-five percent and 71% performed 1-2 strength sessions per week as a team and as extra individual work, respectively. Only 5% of players reported that they did not do any strength work. The number of weekly sessions performed on an individual basis was not significantly different, statistically, from those performed as a team session (1.5 ± 1.1 vs 1.1 ± 0.9 sessions per week, respectively, NS).

The perceptions the players had with respect to muscular strength and the risk of injury was that 84% agreed with the statement that strong muscles are important in the protection against injury whilst only 2% disagreed.

5.4 Discussion

When a sporting behaviour is identified with acceptable certainty the determinants of behaviour must be clarified ⁹⁶. The determinants of preventive behaviour can help to explain why sportspeople decide whether or not to take safety measures. The three factors that have been distinguished as determinants of behaviour (attitude, social influence, self-efficacy) have been described by Kok and Bouter ⁹⁶. A player's attitude towards a certain behaviour or activity is

based on the knowledge and beliefs which that person has concerning the specific consequences that would result from the behaviour or activity; it is the balancing of all the advantages and disadvantages that an individual links to that behaviour. However, in professional football, decisions on the long term health and safety of players are often outweighed by short term benefits linked to team results. When health issues form part of an attitude a healthy motivation is probably a combination of the perceived severity of the health risk, the perceived susceptibility to the health risk, and the effectiveness of the preventive behaviour. The social influence a player is subjected to is often underestimated as a determinant of behaviour. It can lead to behaviour that conflicts with previous attitudes and since professional footballers are predominantly in social situations they will often test their own opinions or behaviour against the standards and values of their fellow professionals. Social influence may have a restraining or stimulating effect on the forming of an opinion and on decision making with respect to certain behaviour, both directly, by what others expect, and indirectly, by what others do. A positive attitude with regard to a particular behaviour and a positive influence from the social environment do not guarantee actual performance of this behaviour. The feasibility of the behaviour will be included in the considerations that proceed the actual decision to perform the behaviour, possible barriers being skill, knowledge, endurance, time or money. The main objectives of this Chapter were to highlight whether professional footballers perceived themselves to be at risk of injury, assess their awareness of certain injury preventative strategies, and determine whether current sports science and medical knowledge on injury prevention was implemented by English professional footballers.

Players believed that the risk of sustaining an injury during a match was greater than that during training ($P < 0.01$). This belief is supported by Sullivan et al.⁶⁷ who reported that injuries were more common during games than during training (62% vs 38%, respectively), and Ekstrand and Gillquist⁵⁴, who found that two-thirds of traumatic injuries sustained by senior players occurred during games. However, 60% of the players in this survey believed that it was also likely that they would sustain an injury during training that would prevent them from being available for selection. It could be expected therefore that players would take steps to minimise this risk of injury during both competitive matches and training.

When considering the aetiology of injuries in matches the role of the opposition players must be considered. In this study only 27% of the players believed that injuries were the result of the actions of other players; a view that is supported by Reilly and Howe¹⁹¹, who suggested that games players were reluctant to recognise intrinsic factors as being responsible for injuries since they attributed 47% of their injuries to chance and 17% to foul play, and studies on Swedish players^{54, 58, 77}, where 30% of the traumatic injuries sustained were due to foul play. However,

the authors here found the player committing the foul usually sustained the more serious injury. It would thus appear that other factors, extrinsic and intrinsic alike, are more likely to play an influential part in injury aetiology, many of these factors being under the direct influence of the players' themselves and therefore able to be manipulated to suit their needs.

Backous et al.⁷⁰ reported that the number of leg injuries to players was increased by failure to wear shin-pads. The use of shin-pads by players in competitive matches is now mandatory and has been since a ruling was made by the game's governing body in 1990, a ruling made with the safety of the players in mind. They are the only piece of protective equipment routinely worn by players; however, their use during training is not compulsory. In the present study 93% of the players said that they never wore shin-pads during training even though over half of the players believed that by wearing them the risk of sustaining a lower leg injury would be reduced; 97% of these players did not wear them while training. Additionally, only one player stated that he was encouraged to wear shin-pads in training. It was reported that for youth players who wore shin-pads only 2.2% suffered an injury to the leg compared with 10.5% for players who sustained an injury while not wearing shin-pads. Ekstrand and Gillquist⁵⁸ found 30% of the senior players questioned wore shin-pads during training, none of the players sustaining leg injuries were judged to be using adequate shin-pads. These authors suggested that most shin-pads worn were insufficient in size, consequently protecting too small an area, and possessed inadequate shock absorbing qualities. Whether this is still the case needs to be assessed. Keller et al.⁶¹ suggested that the use of effective shin-pads, which give the full length of the tibia protection as well as the malleoli, would increase the level of protection players have. It was found that only just over half of the players in the present study always wore shin-pads that protected the malleoli in competitive matches. It is important therefore to raise awareness in this area amongst players and coaches so that this practice is increased and extended to training sessions.

Forces that are generated within the musculoskeletal system can lead to indirect injuries, possibly damaging muscles, tendons, ligaments, joint structures and bone. The authors' current research indicates that almost 40% of all injuries in English professional football are muscular strains, the majority of which occur in the later stages of a game, possibly as a result of fatigue. This is reflected in the players' perception as only 16% disagreed with the statement that the chance of sustaining an injury increased towards the end of a match. However, despite the fact that the major cause of fatigue in footballers is known to be brought about by the depletion of muscular glycogen stores¹⁹², the carbohydrate intake of professional footballers is often inadequate. World class players are reported to only take 47% of their energy in the form of carbohydrate which is substantially less than the recommended level of 60%¹⁹³. In the present study 78% of the players were found to always consume carbohydrates prior to matches which

was encouraging; however, the regularity with which carbohydrates were consumed in the post-match situation and pre- and post-training was found to be inadequate. Although between 73% and 87% of players acknowledged that they received advice on the benefits of carbohydrate intake in these situations, players did not translate this advice into good practice. It appears that the importance of maintaining muscle glycogen stores during training and post-matches is not fully appreciated. Ultimately, without adequate muscle glycogen stores, the ability to perform high levels of work is markedly impaired ¹⁹². With every training session the amount of muscle glycogen available falls, and if the process of incomplete refuelling is repeated over successive days of training there will be a progressive depletion of the muscle glycogen stores, resulting in the lightest of exercises becoming difficult to complete ¹⁹⁴. Wootton ¹⁹⁵ believes that 'the present degree of nutritional naivety, ignorance and confusion displayed by coaches and players alike only serves to further misunderstanding, and ultimately, impairs the development of individual players'. The evidence that is available on the nutritional habits of professional footballers, combined with anecdotal evidence from those who have been involved in football, suggests that there is indeed scope for considerable improvements, which will not only lead to improvements in the performance of players but also in their protection against injury due to a decrease in players' susceptibility to fatigue ¹²⁴. This is speculative but as the role of muscle fatigue in muscle injury has been identified ¹²⁵, it would seem probable that since dietary intervention can delay the onset of fatigue it may also be able to prevent certain injuries.

The other aetiological risk factors addressed in this study were all associated with the training procedures of the players, namely warm-ups, cool-downs, and flexibility and strength training. A warm-up prepares the body for a workout or competition and a cool-down helps the body to recover as body movement assists the removal of by-products from the exercising muscles. In sports generally, a lack or improper use of warm-up and cool-down procedures has been proposed as a risk factor for lower extremity overuse musculoskeletal injuries ^{104, 107}; however, there is a lack of epidemiological evidence to support this. Warm-ups were very much adhered to by the players in this study, possibly a consequence of their beliefs concerning the proposed benefits of warm-ups, only 4% of the players not agreeing with the likelihood that it reduces the risk of injury. Cool-downs though were neglected by the players with the majority of them never performing one and those that did only did so very infrequently. This clearly reflects the result that 70% of the players did not agree with the benefits of cool-downs either post-training or matches. There were various responses given for why players did not undertake cool-downs, with the major response being that they were 'not told to do it', this probably indicating that the benefits of cool-downs are not clearly understood and therefore do not form a part of the philosophy of the coaching staff.

A positive correlation has been reported between muscle strains and tendinitis in the lower extremity with poor muscular flexibility⁵⁸, many authors having suggested that stretching and other flexibility exercises lead to injury prevention and improved performance^{109-111, 115}. The belief is that if the range of movement of a joint is restricted by muscular tightness then the muscle is predisposed to rupture and tendinitis and most probably diminished performance¹⁰⁹⁻¹¹¹. The stretching of muscles before exercise is important because the ability of the musculotendinous unit to absorb energy is directly related to the muscle temperature and muscle length^{123, 138}. In the present study stretching prior to training and matches was extremely well adhered to since it was usually integrated into warm-up procedures. However, after the completion of training or at the end of a match the number of players stretching muscles was very small, although it was greater than the number of players who said they cooled-down. The probable reason for this is that more players do stretch after exercise than actually cool-down, but this stretching does not constitute a cool-down despite the players' beliefs.

No measures of flexibility were taken in this study but work by Ekstrand and Gillquist⁸⁶ found that the flexibility of footballers was less than in age-matched non-players, 67% having tight muscles and therefore making them more vulnerable to injury. The cause of muscle tightness in professional footballers is not yet known, however Inklaar³¹ suggests that muscle tightness could be the result of the muscular strength and power demands that football places upon the body and the poor attention that is generally paid to flexibility training. Fifty-three percent of the players in the current study did not do any flexibility training, with the major reason given for this being that they were 'not told to'. Although 47% of the players did feel that 'poor flexibility would subject themselves to a greater injury risk', surprisingly 54% of these players still did not perform any flexibility work. It was found that players did a greater amount of flexibility work on their own than with the team ($P < 0.01$); however this amount of work was still minimal. It would appear then that since players possess a positive attitude towards flexibility training, and that they would not have any self-efficacy barriers with regards to conducting flexibility training, the reason for their behaviour is probably due to poor appreciation of the benefits by coaches and the presence of peer pressure not to carry it out.

A problem is immediately apparent when the amount of strength training that is conducted by the players is considered. Ninety-five percent of players performed some strength work each week with 84% of them believing that strong muscles provided some protection against injury, possible physiological mechanisms including the increased strength of tendons, ligaments, joint cartilage, connective tissue sheaths, tendon to bone and ligament to bone junction strength and bone mineral content¹⁹⁶. One factor claimed to be responsible for muscle tightness and hence increased propensity to injury is strength work without flexibility work¹¹². The present study

confirmed that professional footballers exposed themselves to this high risk situation, presumably brought about by a lack of knowledge.

Regulations 8 and 11 of the MHSW Regulations require football clubs to provide adequate information and training on injury prevention strategies to players. The present study has identified deficiencies in these areas relating to: (i) the fundamental understanding by players of many of the factors affecting the propensity for incurring injury; and (ii) the guidance and encouragement provided by the management team to players to implement injury reducing procedures. The main deficiencies have been identified as:

- the use of shin-pads providing protection to the malleoli and the use of shin-pads during training;
- carbohydrate intake pre- and post-training and post-matches;
- the implementation of cool-downs post- training and matches; and
- the employment of flexibility work.

These deficiencies indicate a need for wider education of players and coaches in several areas of sports and medical science and a greater understanding of the social influences that players are exposed to that influence their decisions on implementing injury prevention strategies. These deficiencies will clearly have an adverse effect on players' beliefs and behaviour in relation to injury prevention strategies.

Strengths and Weaknesses of the Assessment of Players' Awareness of Injury Prevention Strategies

Although several areas of importance with regard to player safety and the prevention of injury have been highlighted through the current analysis, one aspect of the factors evaluated here was that no consideration was given to their contents, i.e. the amount of carbohydrate consumed in terms of energy percentage, the length of the warm-ups and cool-downs, the exercises they entailed, the stretches that were performed, whether they were contraindicated or not, and the structure of the strength training programmes. Also, it should be acknowledged that the questions were closed response, possibly leading players into their responses; future analysis should allow any other responses to be documented by players. With respect to strength training, regular profiling of the muscle strength of players can identify agonist and/or antagonist muscle weaknesses, or asymmetry between limbs, identifying those players that may be at risk for injury¹⁹⁷, thus giving direction to players' strength programmes. Similarly, flexibility testing can identify areas of poor range of movement enabling the prescription of individualised and more

effective stretching routines. Some of these factors were considered in the previous chapter, and through comparisons with the current work, assessing the reliability of aspects of the player awareness questionnaires, and with the match analysis and injury epidemiological data, further insight to the intrinsic and extrinsic injury aetiological risk factors that professional footballers are subjected to can be highlighted, assisting in the development of injury prevention programmes.

CHAPTER 6

GENERAL DISCUSSION

UK health and safety legislation aims to protect people from injury at work, and since professional footballers are covered by this legislation, there exists a legal requirement for professional football clubs to implement effective health and safety management systems. A risk assessment approach to health and safety issues, as required by the MHSW Regulations, has been undertaken, the study set out to identify aetiological factors associated with injuries to professional footballers in England utilising several risk management processes. Injury frequency and causation was assessed at several levels of competition via match analysis over a three year period, epidemiological injury data collected from professional football clubs playing at different levels and spanning three competitive seasons, club training and players' awareness, beliefs and practices towards the application of strategies for the prevention of injury.

The strengths and weaknesses of the different methods used in the study have been discussed; however, referring to Figure 6.1 (same as Figure 1.2), it can be seen how these different aspects of risk management in professional football interact.

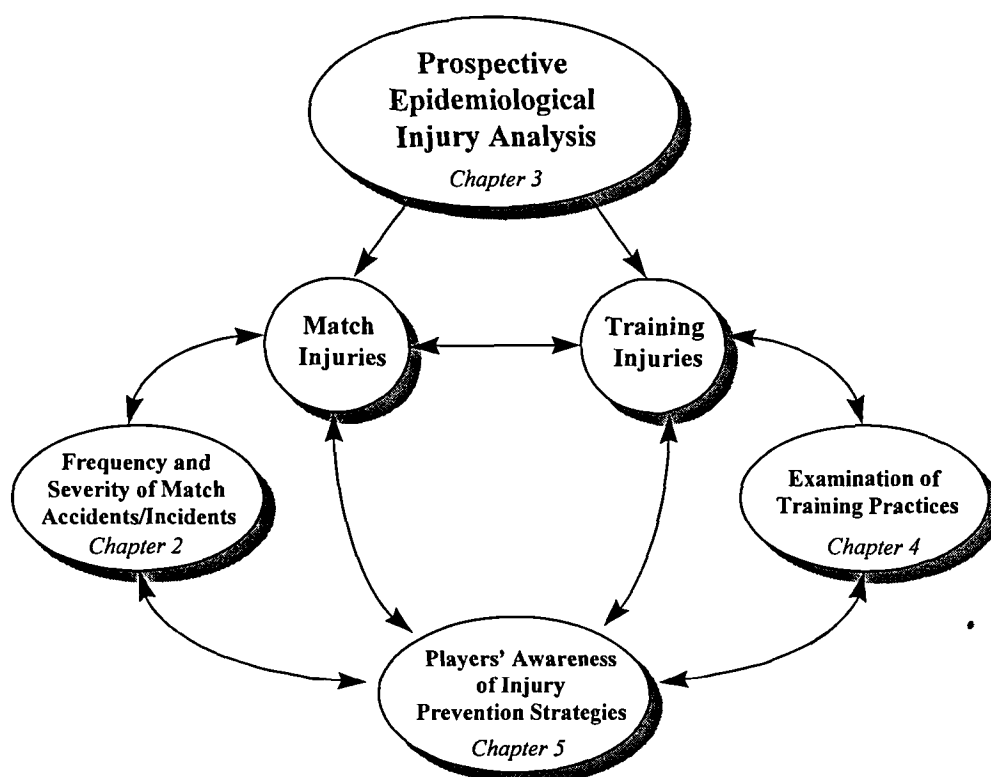


Figure 6.1: Holistic view of the risk management approaches conducted.

By taking this holistic approach and combining the results from the various areas of research, further insights can be made with regard to the identification of the risks for injury, aiding in the development of injury prevention programmes.

Over the three year study period 29 of the televised domestic matches reported in Chapter 2 involved one of the teams that were at the time documenting the injury epidemiology at their club, the results of which are reported in Chapter 3. Table 6.1 shows: the number of players, from the team involved in the injury analysis, who were treated on the field of play during these matches, as identified via the match analysis; whether or not these players sustained an injury that prevented them from playing for 24 hours or more, thus warranting an injury report from the club physiotherapist; the number of injuries sustained by players who were not treated on the field of play; the subsequent removal of all the above identified players; and the severity of the injuries reported by the club physiotherapists.

Table 6.1: Comparison of data obtained from match analysis and club injury reports: number of players treated, their subsequent removal and severity of injury (slight (sli), minor (min), moderate (mod), major (maj)).

Player removal	Treatment during match					No treatment during match			
	Injury not reported	Injury reported				Injury reported			
		sli	min	mod	maj	sli	min	mod	maj
Played on	23	0	0	0	0	4	1	2	0
Off later	1	0	0	1	0	0	0	2	0
Off immediately	0	0	1	0	2	0	0	0	1

From the 28 players who were treated on the field of play only 14% of the players sustained an injury that was severe enough to prevent them from participating in normal practice or matches for at least 24 hours; in these cases none of the injuries were slight and therefore the injured players were absent for more than 3 days. Ninety-six percent of the players who were treated but did not sustain an injury severe enough to warrant an injury report completed the match; none of the players who were treated on the field and sustained a reportable injury completed the match. There were a further 10 players who were not observed to be treated on the field via the match analysis but did sustain a reportable injury, 70% of whom completed the match. These results highlight the reservations previously associated with match analysis in that several injuries occur unnoticed, players sustaining an injury during the course of the game but continuing to play through to its completion without receiving treatment. In this analysis of 29 matches 71% of the reportable injuries would have gone unnoticed without any information from the respective club physiotherapists. Although 40% of these injuries are 'slight', more severe injuries are also

missed, 50% the injuries that went unnoticed being either 'moderate' or 'major'.

From the match analysis alone it is difficult to establish the true extent of many of the injuries without media or physiotherapist correspondence; in this brief analysis, those players who were treated and sustained a reportable injury were either removed from the field of play immediately or later, their injury severity ranging from 'minor' to 'major'. Although the numbers concerned here are small, it should be apparent that the severity of injuries cannot be determined from the player activity subsequent to the injury incident since it is not possible to conclude whether the treated player, being immediately removed from the field of play, will be absent from training for less than one week or greater than one month; it is probable that the degree of caution displayed by the coaching staff with regard to player injuries does vary from club to club, also depending upon the state of the game and the perceived severity of the injury in question. Support for this is given by the results in Chapter 3, one club removing a greater proportion of their injured players immediately in matches, this being a tendency (NS) of the Premiership clubs analysed in general. It may be that there exists at these clubs a greater appreciation of the dangers to a players health and safety associated with an injured player continuing to play in a competitive match or that the greater resources commonly associated with the more elite clubs allows a greater degree of caution to be implemented. The percentage number of re-injuries may provide further insight into the resources available at clubs, the bigger clubs not only having increased medical support and access to a wider range of rehabilitation facilities but also possibly having a greater time span in which to implement rehabilitation programmes, allowing for a more complete recovery of players. On the other hand it may be that the range of player ability is greater in the Premiership clubs placing a greater necessity for any injured key players to be returned to training/playing quickly since it is probable that the difference in ability between the injured player and the proposed replacement increases with level of play. Since injury data was only collected for a significant length of time from 4 clubs at various levels further research should address this issue.

The incidence of injury calculated from the two international tournaments for 'moderate' injuries, as defined in Chapter 2, which could be classed as minor to major injuries, as defined in Chapter 3, was 1048/100000 playing hours which is equivalent to 10.5/1000 playing hours. It has been suggested that this is an underestimate and it has subsequently been shown that several injuries do go unnoticed via the match analysis technique, as illustrated in Table 6.1, which indicates that 60% of minor, moderate and major injuries are not documented. The injury incidence in competitive matches calculated from the injury analysis for all injuries was 27.7/1000 playing hours, and since slight injuries represent approximately 19% of these injuries the injury rate for minor injuries and those more severe is 22.4/1000 hours. If the match analysis

figures are extrapolated to include all 'moderate' injuries then a similar injury rate of 26.2/1000 hours is produced. For all 'injuries' identified via the match analysis a rate of 65-78/1000 player hours was calculated which is 2.3-2.8 times greater than that calculated via the injury analysis. This is not surprising even though it has just been indicated that injuries do go unnoticed; referring to Table 6.1, 28 injuries were documented from the 29 games, however only 14 injuries should have been classified according to the criteria laid down in Chapter 3, i.e. twice as many injuries overall were documented via the match analysis technique which accounts for the greater injury incidence rate via this method. The study indicates that there is an overestimate of the overall injury incidence rate but an underestimate of the rate of 'moderate' injuries via match analysis.

Even though a large proportion of injuries documented in the match analysis were the result of player to player contact, those that actually involved a rule offence were few. From the different levels of competitive matches analysed 18-25% of the treatments observed involved a foul being awarded by the referee, 18% of the injuries reported from matches in Chapter 3 also being the result of a rule offence. The reservations previously discussed from the match analysis concerning the high number of treatments resulting from injury mechanisms involving player to player contact are further highlighted by the figures reported from the individual club injury analysis; 51% of all reported match injuries involved the injured player tackling, being tackled or in a collision. As suggested previously, these injury mechanisms should be carefully analysed and the severity of any subsequent injuries documented, enabling assessments to be made concerning whether any action is required. In the assessment of players' awareness of injury prevention strategies just under one third of those questioned felt that match injuries were caused by the actions of other players, the majority feeling that it was not just a matter of chance and that steps could be taken to prevent certain injuries.

With regards to the injury risk of certain playing positions both the match and injury analyses found defenders to be at a greater risk, however, it is important that future work documents whether injured players were defending or attacking at the time of injury, where on the field they were and also the teams playing formation as all these factors could prove to be influential. From the analysis of players' beliefs to injury susceptibility defenders did not perceive themselves to be at a greater risk than any other player.

Match analysis does allow incidents to be reviewed closely, enabling a clearer picture of any injury mechanism to be constructed, and also with player/physiotherapist co-operation the injury mechanisms that do not involve player to player contact, whether or not they are treated on the field of play, can be more easily identified. In the current study the match analysis also provided

a means of checking the reliability of the injuries reported by physiotherapists with no discrepancies being found. However, in this way only 4 injury reports could be reviewed.

The injury analysis itself illustrates much in terms of injury epidemiology, both similarities and differences to previous work being highlighted. It has been illustrated that differences do exist between and within clubs, further stressing the necessity for a national epidemiological study enabling in-depth comparisons to be made between different playing levels, clubs, and levels within individual clubs. It was reported that two-thirds of all the injuries reported occurred during a competitive match, reflecting the perceptions of players since the majority felt that the risk of sustaining an injury in a match was greater than during training; however, three-fifths also felt that there was still a risk of sustaining an injury during training and that training itself was not injury risk free. It is believed that the risk of injury in training can be reduced by players wearing shin-pads since 93% of players questioned said that they never wore them in training. This was confirmed during the training analysis with a failure to see one player wearing them. Of those players injured during training 86% were reported to not be wearing any shin-pads.

Comparing the injuries reported at some of the clubs with the observations made of their training allowed several inferences to be made. The differences reported between clubs in the training activity at the time of injury can be attributed to the fact that two of the three clubs observed did spend the majority of their time involved in one particular activity; club B players were involved in 11-a-side game situations at some stage during every training session observed, consequently most of their injuries occurred during this activity, as was the case with small-sided games at club D; only club A conducted a wide variety of training activities. In future analyses, in order to accurately assess those training activities that place the player at a greater risk of injury, the length of time spent participating in different activities needs to be documented and the number of players involved throughout the period of injury analysis.

Differences in the nature of injury in terms of proportions were present between the clubs involved in the current study. It is probable that the training practices that the players perform do influence the injury epidemiology reported at clubs. Although no differences were reported between match or training injuries in the current study within individual clubs, overall, the proportion of strains in training were greater than during matches, possible aetiological factors being associated with the strength and flexibility of players and the training content, including warm-ups and cool-downs. With regard to warm-ups players were familiar with the proposed benefits of conducting one, however, the training analysis revealed that they were far from adequate. The proposed benefits associated with performing a cool-down were not as well understood and consequently in most cases they were not conducted. Similar comparisons

between the training analysis and player perceptions revealed that the proposed amount of flexibility and strength work conducted to be lower than was reported by players, possibly having a large influence on the types of injuries sustained during both matches and training, although without player profiling this cannot be substantiated.

The tendency (NS) for the differences observed in the proportion of sprain injuries during training at two of the clubs (A and D) could be attributable to several factors, such as the playing surface conditions on the training pitches, whether or not players wore any kind of ankle or knee supports/strappings, and the number of players with previous ankle or knee sprain injuries since it has been reported that those ankles which have previously been sprained are more susceptible to sprains than those which have not⁵⁴; players who had previously sustained an ankle sprain were reported to be at a 2.3 times greater risk of sustaining another one⁷¹. This is probably also partly attributable for the different proportions of knee injuries reported between clubs. It would be worth documenting in future epidemiological research how many players from the study group regularly wear a joint support or strapping during training and matches, similarly the number of times particular training surfaces are trained upon, allowing for valid statistical calculations assessing their influence on the incidence of injury to be made.

Following on from the general pattern observed for all the injuries in the study, a greater proportion of contusions were observed during matches compared to training at all clubs. The discussion points made in Chapter 3 were supported by the subjective training analysis. The intensities of training sessions appeared to be lower than that regularly seen in competitive matches with fewer player to player contacts. It is probably the greater number of contusions as a result of the greater number of contacts in matches compared to training that influences the beliefs of players and their perceptions of injury risk during these activities. Two clubs (A and D) sustained more strain injuries in training than was expected, both clubs being involved in the top two divisions. The warm-ups and cool-downs at club D were assessed as being inadequate which is most probably influential, however the reverse was true of club A. It was noted at the latter club that when the 1st team coach did not conduct the training session the training was not as extensive; it may be that the majority of strain injuries took place during these sessions or reserve team sessions, however this data was not available. This same argument applies to the differences in injury mechanisms reported at club A, and also possibly explains the differences observed in training injuries between playing seasons at club A regarding their nature, location and mechanism. The lower proportion of running injuries reported in training at club D may appear surprising considering the training performed by their players, however the problems in monitoring the intensity of the training has already been discussed and it may be that players only sprint on occasions, this usually being the most common activity at the time of running

injuries. Differences in injury mechanisms between training and matches at individual clubs follow similar patterns to that discussed for all injuries previously, the same proposed explanations applying here. However, following the training analysis and its adequacy in terms of injury prevention, further work needs to assess more accurately the training content and also the preparatory activities conducted for competitive matches as this may be far superior to that observed during training. It would also be worth documenting player activity at the completion of competitive matches as this may have an influential effect on the players propensity to injury in subsequent training sessions.

Different injury profiles observed within clubs between different seasons can partly be explained by the results obtained via match analysis. Two of the clubs involved in the injury analysis were either promoted or relegated during the study period. Club A sustained fewer contusion injuries in the 1996/1997 playing season during matches than during the previous season when they played at a lower level. The greater number of treatments that were documented from the Division One match analysis that involved player to player contact compared to the Premiership (74% vs 66%) could account for the difference, with also the tendency (NS) for a greater number of free-kicks per game being reported in Division One, both of which could be suspected to lead to a greater number of player to player contacts and subsequently more contusions at the lower level. As previously stated it is not possible to make accurate conclusions since the level (1st team or reserve) at which the injured player was playing at the time of injury was not documented.

Due to the different injury profiles observed in different clubs and also within the same club over different seasons and during the same season between squads, it appears that it would be worth while constructing a daily diary of the player activity in the different training groups. This approach has previously been applied to professional footballers ¹⁹⁸ and athletes ¹⁶¹, both authors detailing the activity profiles of the respective study groups. The benefits of match analysis in conjunction with injury reports have previously been discussed.

A general pattern throughout the analyses has indicated that during matches the players' susceptibility to injury increases with time, the match analysis showing a greater number of players to be treated in the second half of matches and the injury analysis finding a major proportion of injuries to occur in the final 30 minutes of matches, especially the final 15 minutes. The importance of an adequate dietary intake in reducing fatigue has been discussed, both the training analysis and report on player perceptions indicating that there is a poor adherence to carbohydrate replacement/loading strategies employed by players, especially in situations other than prior to matches. This issue is in need of further assessment, addressing factors such as the

importance players associate with their dietary needs, their actual dietary intake and what foods and in what quantities they perceive as being sufficient; the difficulty being converting the theory into practice.

The discussion has demonstrated how the different approaches taken in this study inter-link with one another, information from one aspect being able to broaden the picture given by another. The work highlights the need for this multidisciplinary approach, stressing the importance of comparing the injury mechanisms documented via match analysis with more in-depth medical reports, and the need to perform an objective analysis of the training conducted by clubs, profiling the players and correlating proposed aetiological factors with the injury data.

Although the current work did not involve any analysis of the financial consequences of injuries to professional football clubs, it is felt that until this has been conducted difficulties will be experienced in attempting to implement changes in clubs aimed at reducing player injuries. The financial loss to professional football clubs due to injuries is not known. There have been reports of insurance companies paying out large sums of money ³², but these most probably do not compensate for the direct (e.g. medical treatment, player wages while unable to play) and indirect (e.g. loss of matches, buying a replacement player) costs incurred by clubs. In a Swedish Division IV team (semi-professional) Ekstrand ⁷⁷ reported a loss of \$US 420,000 due to medical care costs and sick leave over one season.

In industry the subject of the costs of accidents is more clearly understood and appreciated. Compensation received by people injured at work often involves large sums of money; however, the extent of the losses from less serious injuries is not so well known. The HSE's Accident Prevention Advisory Unit ¹⁴⁸ conducted a series of case studies, the aim being to accurately identify the full cost of accidents. The average annualised reported loss for each company was over £1.2 million. In football, equivalent costs may involve medical fees, increased insurance premiums and reduced income from lower match attendances. Few clubs, if any, have the mechanism or resources to identify the losses separately and probably none actually identify and examine them systematically. In professional football, especially at the highest level, the financial consequences of injuries to clubs is expected to be proportionately more than in industry as the relative number of injuries in football greatly overshadows industrial figures. To accurately identify the full cost of injuries to a professional football club would require an in depth investigation.

It has been suggested that by applying a risk management policy the risk of injuries in professional football should be reduced. Of those industrial organisations that achieve high

standards of health and safety, common characteristics in the health and safety policies they adopt are displayed. There is no reason why the same principals cannot be applied to professional football; a brief overview of 5 main principles that could be adopted are discussed below.

1. *The importance of players to professional football clubs.*

In industry those with successful health and safety policies hold the belief that people are their most important asset. Although this appears obvious this must also be the case in professional football since without the players there would be no business; unfortunately this does not always seem to be the case as suggested by the present research. If the risks of injury in professional football are controlled then the general health and well-being of the players should not suffer. Health and safety policies concerned with the prevention of injury and ill health are required by health and safety legislation. Players should be looked after in terms of training regimes, prophylactic programmes being implemented, and educated in areas such as health promotion as discussed in Chapters 4 and 5.

The ultimate aim is a football club in which accidents and ill health are eliminated, players being satisfied with their lifestyle having both a strong physical and mental well being, a benefit to not only the players themselves but also the club. The club should not only recognise that they are behaving ethically and responsibly by achieving this, but they should also see the positive benefits which can accrue from a fully fit, athletic, enthusiastic and committed team. The needs of the players and the prosperity of the club go hand in hand.

2. *Avoiding injury - the total loss approach.*

Injuries to players in a professional football club result in unnecessary financial losses. Under the total loss approach, previously discussed in Chapter 2, accidents do not only include those circumstances which actually cause injury but also every event having the potential to result in injury, i.e. non-injury accidents or near misses. This total loss approach is based on research into accident causation. From accident ratio studies the relationship between serious and minor accidents and other dangerous events have been assessed ¹⁴⁸. There were several significant conclusions which are supported by the current research undertaken in English professional football:

- there are constantly a greater number of less serious events occurring than more serious ones;
- 'no injury' incidents or 'near misses' had the potential to have more serious consequences;
- all events represent failures in control and can be used as a learning experience through

which control can be improved; and

- to be effective, health and safety policies need to examine all unsafe events and their causes, a means of not only establishing control but also of measuring performance.

The examination of the causes of all injuries, and potential ones, can provide valuable insights into inadequacies in risk control and action which could prevent future injuries. For example, if a player does not wear any protective shin-pads while training, when he comes into physical contact with another player he may fracture his tibia and be injured for twelve months, he may only receive a slight contusion and subsequently miss five days, or he may escape unscathed. Effective prevention and loss control must focus on the cause of the accident not its results. The consequences of accidents are often matters of chance over which there can be little control.

From this approach, learning from both accidents and incidents achieves effective control. The emphasis is on preventing accidents by identifying risks and the sources of potential injury. If an investment is made to reduce injuries then this probably contributes to the club's profits and is therefore cost-effective.

3. *Accidents are caused by absence of adequate management control.*

Accidents and incidents are seldom inevitable random events. Failures in control are usually responsible and the causes are multiple. Although the immediate cause of an event may involve a player, the events usually arise from failings within the football club which are the responsibility of the management. Policies should place a heavy emphasis on effectively controlling players, exploiting their strengths and minimising the influence of their limitations by structuring their training appropriately.

It is critical that the way in which 'human factors' affect health and safety performance is understood. There are three key factors which influence the behaviour of a football club:

- the football club: organisational factors have the major influence on the behaviour of players. The influence of the club should not be overlooked, especially in the design of training programmes and the safety culture it promotes e.g. warm-up/cool-down, strength and flexibility training and nutritional strategies, ensuring player involvement and commitment at all levels, deviation from set standards being unacceptable.
- playing football: the job itself has inherent risks so it is necessary that there are no mismatches between the players' capabilities and their roles in the team. It is important that players are not overloaded, for example the number of games children and adolescents play should be controlled. If there is a mismatch between an individual and

their job requirements then there is a potential risk for injury. It should be remembered that all coaches owe a duty of care to their athletes; the standard of that care being measured against the coach's peers. A coach claiming to have qualifications or special skills will be rated higher and as such will be judged against the reasonable person who has the same skills and qualifications. In the case of a coach letting qualifications lapse, then they will still be judged by the standards of their qualified peers. Because of this people involved with professional sportspersons should not become risk adverse; their duty is to develop the skills of their athletes, challenging them, pushing them to their full potential. Coaching staff must make judgements, balancing between taking the necessary risk, to develop an athlete physically and mentally, while ensuring the standard of care is met.

- the player: the players themselves will have their own strengths and weaknesses with regards to the demands of training and playing professional football. These include both physical and mental attributes, the majority of which are amenable to modification or enhancement through training and experience. Weaknesses should be identified by the management and rectified, thus preventing the players being subjected to any unnecessary risks.

4. *The importance of organisational factors.*

For the management of risks and the reduction of injuries to be successful the creation of an effective organisation for health and safety is essential. It is an underlying belief that effective control of health and safety is achieved through co-operative effort at all levels in the organisation. A positive health and safety culture is crucial, and this can only happen through the active and continued commitment of the management. They should effectively communicate their beliefs which underlie the club e.g. players, coaches, manager, physiotherapist(s) and chief executive, health and safety policy. The whole club is required to share the management's perception and beliefs about the importance of health and safety and that the policy objectives need to be achieved.

5. *A systematic approach.*

Using appropriate procedures for analysis, risks can be identified systematically and objectives and performance standards can be established. Using risk assessment techniques areas for action can be prioritised. Structured monitoring should be planned appropriately, planning being critical to effective policy implementation. The practical implications of health and safety policies need to be thought through so as to avoid conflict with other demands in professional football. However, it would appear that effective policies would enable players to match the demands of playing professional football more adequately. The football club should be committed to

continuous improvement, always striving for high standards. Clubs can learn from the many injury experiences they have already experienced, these possibly just being warning signs of the potential for a more serious injury. Performance should be reviewed regularly so that policies can be developed accordingly.

Summarising, effective health and safety policies can contribute to the performance of a football club on the pitch, and consequently as a business, by:

- supporting the development of professional footballers;
- minimising the financial losses which arise from avoidable injuries;
- recognising that accidents and incidents result from failing in management control and are not just the fault of individual players;
- recognising that the development of a culture within a club supportive of health and safety is necessary to achieve adequate control over injury risk factors;
- ensuring a systematic approach to the identification of injury risk factors and the allocation of resources to control them; and
- supporting quality initiatives aimed at continuous improvement.

It is apparent that a preventative approach towards football injuries should have a high priority, prevention being better than cure. An orderly progression has been followed and should continue to do so. The following summarises the steps that have been taken (1-2) and the procedures that need to follow (3-4):

1. identify the extent of the problem of injuries in English professional football (hazard identification);
2. identify the potential influential factors and mechanisms (risk assessment);
3. introduce preventive measures that are likely to reduce the future risk and/or severity of injuries (risk minimisation); and
4. re-evaluate, the maintenance of injury records being crucial, allowing the effectiveness of preventive measures and implemented management plans to be assessed.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

It has been demonstrated that there exists a problem with regard to the excessive number of injuries that occur in English professional football. Risk factors have been highlighted and steps should be taken to minimise the hazards to which professional footballers are exposed, decreasing the risk of injury and ill-health to all players. Some of the health and safety legislation professional football clubs should adhere to has been highlighted, the implementation of which aims to protect people from injury while at work.

An overall injury rate of 8.5/1000 playing hours was calculated from the injury analysis, injury rates during training and matches being 3.5/1000 and 27.7/1000 playing hours, respectively. Differences between studies do exist, suggested explanations involving the intensities at which the matches are played and training is conducted in different countries, the two injury rates possibly being linked. It was calculated that during a typical playing season each club could expect every single player to be unable to train or play competitively for approximately 1 month, the average injury lay-off being 15 days. Under RIDDOR ²⁷ 84% of all the injuries documented in the injury analysis were required by law to have been reported to the appropriate authority. Compared to the accident statistics issued by the Health and Safety Commission the injury frequency rates in football calculated from the match analysis are three orders of magnitude higher than in many industries, the injury analysis results calculating that the average person who works a 40 hour week in industry would expect to obtain an 'over 3-day injury' every fourth week.

Two-thirds of the injuries were reported to occur during competitive match play, the remainder during training, thus it was not surprising to find injury peaks during match intensive periods. Assessed as the number of competitive match injuries per match per month the first month of the playing season was found to be the month during which players are at the greatest risk of injury during matches. The highest incidence of training injuries was reported to occur during the pre-season period. The training conducted during the close- and pre-season periods could be influential upon both training and match injuries and is in need of an objective assessment.

The nature of injuries were predominantly strains (41%), sprains (20%) and contusions (20%). Eighty-seven percent of the reported injuries were located in the lower extremity, the thigh (23%) being the most common followed by the ankle (17%) and knee (14%). Almost half of the

injuries occurred during non-contact activities involving running, shooting, turning or a combination of several activities with only 18% of the competitive match injuries being the result of a rule offence; however, there was still a large proportion of competitive match injuries that involved player to player contact mechanisms which are in need of analysis. The match analysis reported between 18% and 35% of all treatments received on the pitch to be the result of a foul, with 60% of all other treatments still being associated with player to player contact. Only 1.7-3.0% of fouls lead to a player requiring treatment, consequently no correlation was reported between free-kicks and the treatment of players. Following the assessment of training routines it was concluded that on the whole attention paid to training preparation and after training player care was inadequate; flexibility and strength training was almost non-existent. This, together with the poor adherence to the wearing of protective equipment, could contribute to the high number of strains and lower extremity injuries observed. It is believed that the wearing of shin-pads, particularly those providing protection to the malleoli, would reduce the number and severity of lower-leg injuries in training, especially during practices where there exists a high probability of player to player contacts. The different injury profiles documented between youth and senior players also indicates the probable necessity for players to follow thorough flexibility programmes throughout their careers to decrease their susceptibility to injury, especially muscular strains. The suspected inadequacies in the diets of professional footballers is probably reflected in the greatest injury incidence rates occurring in the final 15 minutes of competitive matches; if muscle fatigue is an aetiological factor then the importance that is placed upon a players fitness is further emphasised and the necessity for appropriate dietary intervention to take place. With regards to the possible problems associated with dehydration individual players should have their sweat loss rates assessed enabling the identification of those requiring more fluid intake, minimising performance decrements. Twenty-two percent of the injuries were reported to be re-injuries which is believed to be an underestimate. The need for controlled rehabilitation and strict adherence to programmes has been discussed, the criteria that are set for players to achieve before returning to regular training being in need of assessment.

The requirement under Regulations 8 and 11 of the MHSW Regulations for football clubs to provide players with adequate information and training on injury prevention strategies has been found not to be strictly adhered to; the fundamental understanding by players of many of the factors affecting the propensity for incurring injury is limited together with the guidance and encouragement provided by the management team to players to implement injury reducing procedures. The assessment of players awareness towards injury prevention practices emphasised the necessity for educating all those involved in training, and the influences the portrayed beliefs of managers and coaches have on the players. It appears that the need for education and a change in awareness and beliefs does not solely refer to coaches, players and

managers but also referees; prior to a competitive match played on hard frozen ground in January 1997, a referee was quoted as saying “players will be okay if they only play at 70%”¹⁹⁹.

Further Research and Recommendations

Physiological

- Any miss-match between the demands of training and matches could be obtained by conducting an objective assessment of the intensity of training sessions simply by monitoring players’ heart rates via short-range telemetry techniques, comparing to similar assessments conducted during matches. More in-depth physiological assessments could be conducted if required. There exists a need for coaches, medical and fitness staff to optimally prepare players for competition without excessively creating overuse injuries.
- Close-, pre-, and in-season training programmes need to be assessed to determine whether players are being adequately prepared for competition. Physiological assessments of players during different stages of the season would allow variations to be tracked, enabling the effectiveness of specific training programmes to be evaluated objectively, quantifying changes in performance.
- Via player profiling, differences in specific fitness parameters between individual players can be assessed and correlated against the incidence of different injuries, also allowing comparisons between youth and senior players and different playing positions. Muscular imbalances, which possibly predispose senior players to muscular thigh strains, especially to the posterior thigh, can be identified by player profiling. Also differences between the dominant and non-dominant lower extremities can be identified. The development of individual physiological player profiles with prospective injury surveillance will enable the development of optimal individual training programmes following the identification of player strengths and weaknesses, possibly leading to the prevention of certain types of injuries. Early signs of overtraining could also be detected through regular profiling by monitoring a player’s health status.
- Benchmarking a player’s performance can be used to monitor how the injured player is responding to treatment, and in the event of a long layoff due to illness or injury, comparisons can be made to a ‘base value’ giving an indication of when a player is back to his original fitness.
- Dietary analysis of players pre- and post- training and matches should be undertaken to identify whether or not inadequacies exist.

Biomechanical

- Biomechanical/orthopaedic assessments of players should form a part of the player

profiling previously referred to, proposed risk factors being correlated with the injuries players sustain. This will enable some risk factors to be identified following which their modification could lead to the prevention of injuries. All professional players should be screened, aiming to identify factors that may lead to future injury, current injuries or past injuries not fully rehabilitated.

Epidemiological

- A longitudinal study of injuries in English professional football is required, forming part of a health surveillance strategy aiming to provide a positive protection for players from potentially serious career threatening chronic injuries. Following the completion of playing careers players should be continued to be tracked, aiding in the development of an understanding of the consequences of previous football activity later in life e.g. the development of chronic brain damage from acute head injuries possibly being exacerbated by further repetitive heading of the ball. The study will also form part of the overall risk management process, monitoring injury rates over successive seasons allowing assessments to be made of implemented injury prevention strategies. Future injury reports should be expanded to include:
 - ◆ the size of the squad at the club of the injured player as this could influence the time taken for him to return to regular activities, possibly being returned prematurely under club pressure against the long-term health interests of the player;
 - ◆ the level of competition played at the time of injury to allow comparisons between different divisions to be made;
 - ◆ the injured player's date of birth to allow assessments to be made between age groups. The research should look to be expanded so as to include all professional players, all youth trainee players and eventually the different age groups involved in the schools of excellence associated with professional football clubs;
 - ◆ training injuries should identify whether the injury occurred during a morning or afternoon session and whether or not it was the first or second session of the day, the length of the sessions also being indicated;
 - ◆ match injuries should document the area of the pitch in which the injury occurred and whether the injured player was defending or attacking as this would give a better indication of whether or not different playing positions are subject to greater risk;
 - ◆ during matches document whether at the time of injury the injured player's team had available substitutes since it is probable that if all the available substitutions have been made a players health and safety is compromised at the expense of keeping 11 players on the field of play;

- ◆ as well as classifying injuries according to time loss the standard medical classification should also be utilised enabling comparisons to be made between the rehabilitation time of similar injuries; and
- ◆ player involvement in (i) warm-up activities prior to the training session or match in which the injury occurred, (ii) cool-down activities at the end of the previous training session or match, and (iii) a fitness test prior to the game in which he was injured should be indicated.
- To avoid having to extrapolate results, daily reports should be made documenting the number of players training and the length of sessions.
- Injuries occurring through player to player contact, which do not involve a rule offence, should have the mechanisms assessed and the injury severity and frequency documented to identify whether the current laws of the game need to be modified because of current risks to players' health and safety.
- Rehabilitation protocols should be assessed for their effectiveness. It has previously been reported that for players with a history of ankle problems the use of ankle disk training was the best means of preventing recurrent sprains by reducing functional instability¹²⁸. The authors suggested that co-ordination training on an ankle disk ought to be included in the rehabilitation of ankle injuries to prevent functional instability. It may also be done prophylactically by players with previous ankle problems in order to break the vicious circle of recurrent sprains and feeling of giving way.

Awareness of Injury Prevention Strategies

- Following the assessment of professional footballers' awareness and application of injury prevention strategies it is recommended that other professional bodies involved in football are approached and surveyed with similar issues being addressed. Appropriate bodies to approach include club chairmen, managers, coaches, medical staff, sports science support staff, The Football Association, The Football League, The Premier League, The League Managers Association, The Referees Association and The Football Licensing Authority.

Educational

- Health education needs to aim at eliminating behavioural factors that threaten health and stimulate those factors that have a positive effect on the 'health behaviour' of those involved in football. It is probable that the incidental transfer of information will not be sufficient to change beliefs and behaviour, the requirement being for educational interventions to be spread over longer periods of time. Managers, coaches and players need to be educated in the benefits of specific practices, including warm-ups, cool-downs, stretching techniques, flexibility training, strength training, nutritional strategies and

principles of fitness training. Due to the multidisciplinary nature of health education, interventions may consist of several methods and techniques, for example, the player profiling referred to above would adequately serve as an educational tool.

Equipment

- Research is required into the effectiveness of different types of shin-pads in the prevention of contusions and fractures to the lower leg and ankle.
- Research is required into the type of footwear and incidence of certain types of injury. Different stud designs, the number and type of studs, their size and position, the shape of the footwear used and their frictional properties on different surfaces are in need of further examination, especially in relation to the incidence of sprain injuries to the knee and ankle and overuse injuries.

A computer database needs to be developed to incorporate all of the proposed research conducted above, bringing together results from player screening/profiling, training histories and prospective injury histories, assisting in the identification of internal and external risk factors for football injuries. It is only by relating the injuries to corresponding population denominators that injury rates can be estimated and important risk factors and high risk players can be identified⁹³. Over time the data collected will reveal optimal player profiles and conditions that match up to the demands of professional football to enable players to remain injury free. Ultimately performance will improve bringing enjoyment to all those involved.

Many of the proposals above have subsequently been implemented, especially the epidemiological research through the Audit of Injuries presently being conducted by the English Football Association's Medical Education Centre, involving all registered professional players in England and Wales. The first year of the study runs from July 1997 through to the end of May 1998, incorporating both the pre-season and in-season periods, with the study having prospects of being extended into a longitudinal project. The New Generation of Courses also implemented by the English Football Association is one step that has been made towards educating those involved in the training of players in the principles of fitness and training, hopefully bridging the gap that currently exists between the knowledge of researchers and practitioners, highlighting the importance and benefits associated with sports science interventions in professional football. The need for sports science input into the training procedures is fundamental to the development of players and reducing their susceptibility to injury. Football clubs are slowly being transformed, especially those playing at the elite level, and it should be realised that it is going to take time for the footballing culture in England to change after having stood still for many years. Referring to comments made by the current Blackburn Rovers manager, Roy Hodgson, prior to the start of

the 1997/1998 Premiership campaign, he stated that experts such as doctors, physiotherapists, fitness trainers and masseurs need to be available to players at all times²⁰⁰. He went on to say:

“Yes it costs a lot of money but, then again, the players cost a lot of money..... If a player doesn’t play for two or three weeks and we get bad results, that costs a lot of money. This has to be balanced out and weighed up. There is always a reluctance to spend money on staff and a willingness to spend it on players and these things need to go hand-in-hand. There is no point in having top-class artists and not looking after them.”

It is hoped that the current work and future projects alike signify the need for change, providing objective data on which decisions can be based and procedures implemented, an objective outlook having been lacking in the past. Significant changes relating to the health and safety of professional footballers need to be made, the necessity remaining for the cost and debilitating effect of injuries and the continual threat of expensive legal law suits being made aware to those involved and in positions to make decisions and consequently change. Through education and appropriate modifications longitudinal research could identify the progress made in lowering the overall injury prevalence seen in English professional football, ultimately prolonging the careers of professional players, decreasing the current percentage that have to retire from their profession because of injury, generally increasing the productivity of a professional football club and the quality of life of players themselves.

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PREMIERSHIP SEASON 1996/1997

TEAMS: Blackburn Rovers vs Arsenal

DATE: 19th November, 1996

1st Half Free-kicks:

3A, 12A, 17A, 25B, 29A, 39B, 46B

Total: 7: 3B, 4A

2nd Half Free-kicks:

47B, 52B, 59A, 69A, 75B, 76B, 84A, 91A

Total: 8: 4B, 4A

MATCH TOTAL: 15: 7B, 8A

TREATMENTS

<i>Time</i>	<i>Free-kick</i>	<i>Squad no.</i>	<i>Position</i>	<i>Condition</i>	<i>Mech.</i>	<i>Locat.</i>	<i>Contact</i>	<i>Notes</i>
18	No	1A	GK	OI	Collision	Leg	Yes	-
39	For	6B	D	PO	Heading	Head	Yes	-
75	No	10A	F	OL	Running	Leg	No	*

LOCATION**1. Date** ____/____/____**2. Venue**
☐ home; ☐ away; ☐ training ground;
☐ other (specify) _____
3. Playing surface type
☐ grass; ☐ track; ☐ indoor;
☐ all-weather; ☐ artificial
4. Playing surface condition
☐ dry; ☐ frozen; ☐ wet/muddy; ☐ N/A
PLAYER IDENTIFICATION**5. Squad number** _____**6. Injury number** _____**7. Playing position when injured**
☐ GK; ☐ defence; ☐ midfield;
☐ attack; ☐ N/A
INJURY DESCRIPTION**8. Nature of injury**
☐ abrasion; ☐ blisters; ☐ concussion;
☐ contusion; ☐ dislocation; ☐ fracture;
☐ laceration; ☐ overuse; ☐ sprain;
☐ strain; ☐ other (specify) _____
9. Anatomical location*head, face and neck*
☐ head; ☐ face; ☐ neck
upper extremity
☐ shoulder; ☐ elbow; ☐ forearm;

☐ wrist; ☐ hand
trunk
☐ chest; ☐ back; ☐ abdominals
lower extremity
☐ hip; ☐ groin; ☐ thigh; ☐ knee;

☐ lower leg; ☐ ankle; ☐ foot;

other (specify) _____
10. Body side of injured
☐ dominant; ☐ non-dominant; ☐ N/A
11. Was player removed from play
☐ immediately; ☐ later; ☐ not at all
12. Degree of injury¹
☐ slight; ☐ minor; ☐ moderate; ☐ major
13. Was this a reinjury
☐ yes; ☐ no; ☐ unknown
14. Medical classification of injury**INJURY DESCRIPTORS****15. Time of injury (minutes)**
☐ 0-15; ☐ 15-30; ☐ 30-45;
☐ 45-60; ☐ 60-75; ☐ 75-90; ☐ N/A
16. Activity
☐ competitive game;
☐ 11-a-side practice game;
☐ small-sided game; ☐ exercise; ☐ drill;
☐ other (specify) _____
17. Injury mechanism
☐ tackling; ☐ tackled; ☐ running;
☐ falling; ☐ shooting; ☐ dribbling;
☐ jumping; ☐ landing; ☐ heading;
☐ turning; ☐ collision; ☐ overuse;
☐ other (specify) _____
18. Refereeing decision
☐ free-kick for; ☐ free-kick against;
☐ no free-kick; ☐ N/A
19. Playing equipment*shoes*
☐ studs; ☐ moulded; ☐ flats;
☐ running shoes
shin pads
☐ worn; ☐ not worn
1. Degree of injury classification:

slight: absent from normal practice for 1-3 days.

minor: absent from normal practice for 4-7 days.

moderate: absent from normal practice for 1-4 weeks.

major: absent from normal practice for more than 4 weeks.

Any questions regarding this questionnaire
 please contact Richard Hawkins on
 01509 263171 ext. 4684

TRAINING ANALYSIS*Date:* 18.3.97*Squads:* 1st ✓; res ✓; yts ✓*Daily session number:* 1✓;2 -/ 1✓;2 -/ 1✓;2 -*No. of players:* 17 / 9 / 14*Start time:* 10:33 / 10:30 / 10:30*Finish time:* 11:32 / 12:10 / 12:10**Equipment***No. wearing shin pads:* 0 / 0 / 0**Warm-up***Prior activity:* yes -; no ✓*Type:* passive -; general -; specific -*Warm-up:* individual -; sm. gps -; lg. gp ✓*Type:* general -; specific ✓*Start time:* 10:33*Finish time:* 11:00*Structured:* yes -; no -; partly ✓

activity	time
running with ball, ½ a pitch at a time (2 groups of 8, 4 at each end)	4 min
as above, increase passing distance	2 min
as above, 2 touch	4 min
as above, 1 touch	2 min
*1	
big circle, keep ball, 2 in the middle	12 min

Stretching: static ✓; ballistic -; PNF -

muscle group	time/reps
*1	
own stretches, generally not held long enough	2-3 min

Session

activity	time
9-a-side, ¼ pitch, 3x10 min	30 min

Nutrition*Fluid available:* yes ✓; no -*Type:* water -; CHO solution ✓; n/a -*No. players drinking:* majority after training**Cool-down***Start time:* told to stretch before leaving training pitch (approx. 4 players do)*Finish time:* -*Cool-down:* general -; specific -*Structured:* yes -; no -; partly -

activity	time

Stretching: static ✓; ballistic -; PNF -

muscle group	time/reps
hamstrings (leg on bar)	approx. 8-10 sec

Notes

During the warm-up and main session some stretches were conducted by players while waiting for a ball but this was all very rushed (2-3 sec).

4 players worked after the session, 2 hitting 40 yard balls and 2 doing 10-15 yard sprints (x6). No stretching was conducted after.

FOOTBALL AND INJURIES

Aim: An assessment of professional footballers' opinions towards injury.

All questions are strictly confidential. Please be as truthful as possible, and only tick one box per question unless otherwise indicated. Thank you for your co-operation.

PART A. 1. Age (yrs): _____ 2. Number of years as a professional: _____

3. League: **premier** ☐ **1st** ☐ **2nd** ☐ **3rd** ☐ 4. Playing position: **goalkeeper** ☐ **defender** ☐ **midfielder** ☐ **forward** ☐

5. How many injuries have you received over the last 12 months during training or a competitive match that have resulted in you being unavailable for selection?
i. *competitive match injuries*: 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ >5 ☐
ii. *training session injuries*: 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ >5 ☐

PART B.

- | | always
(100%) | very often
(~75%) | often
(~50%) | sometimes
(~25%) | never
(0%) |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 6. Do you wear shin-pads in training? | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7. In competitive matches do you wear shin-pads with ankle protection? | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8. Do you consciously consume carbohydrates (e.g. bread, pasta, rice, potatoes, chocolate, sugar) in the following situations? | | | | | |
| i. <i>pre-training</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| ii. <i>post-training</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| iii. <i>pre-match</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| iv. <i>post-match</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9. Do you have a warm-up period prior to: | | | | | |
| i. <i>training</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| ii. <i>matches</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. Do you have a cool-down period at the completion of: | | | | | |
| i. <i>training</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |
| ii. <i>matches</i> : | ☐ | ☐ | ☐ | ☐ | ☐ |

Appendix 4

	always (100%)	very often (~75%)	often (~50%)	sometimes (~25%)	never (0%)
11. Do you stretch the major leg muscles in the following situations?					
i. <i>warming-up prior to training:</i>	☐	☐	☐	☐	☐
ii. <i>warming-up prior to matches:</i>	☐	☐	☐	☐	☐
iii. <i>cooling-down after training:</i>	☐	☐	☐	☐	☐
iv. <i>cooling-down after matches:</i>	☐	☐	☐	☐	☐
12. Do you undertake flexibility training (not included as part of a warm-up or cool-down)?					
i. <i>times per week as part of a team session:</i>	0 ☐	1 ☐	2 ☐	3 ☐	>3 ☐
ii. <i>times per week as extra individual work:</i>	0 ☐	1 ☐	2 ☐	3 ☐	>3 ☐
13. Do you undertake strength training in the gym?					
i. <i>times per week as part of a team session:</i>	0 ☐	1 ☐	2 ☐	3 ☐	>3 ☐
ii. <i>times per week as extra individual work:</i>	0 ☐	1 ☐	2 ☐	3 ☐	>3 ☐

PART C. In the following questions tick the description which most closely matches your opinion of the statement.

	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
14. The chance of sustaining an injury during training that prevents you from being available for selection is likely.	☐	☐	☐	☐	☐
15. The chance of sustaining an injury during a competitive match that prevents you from being available for selection is likely.	☐	☐	☐	☐	☐
16. There is a greater chance of sustaining an injury during a competitive match than during training.	☐	☐	☐	☐	☐
17. Injuries are a consequence of the actions of other players.	☐	☐	☐	☐	☐
18. The risk of lower-leg injuries in training is reduced by wearing shin-pads.	☐	☐	☐	☐	☐

	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
19. Injury is more likely towards the end of a match.	☐	☐	☐	☐	☐
20. The risk of injury is reduced by thoroughly warming-up and stretching prior to:					
<i>i. training:</i>	☐	☐	☐	☐	☐
<i>ii. matches:</i>	☐	☐	☐	☐	☐
21. The risk of injury is reduced by thoroughly cooling-down and stretching after:					
<i>i. training:</i>	☐	☐	☐	☐	☐
<i>ii. matches:</i>	☐	☐	☐	☐	☐
22. Players with poor flexibility are more likely to get injured than those with good flexibility.	☐	☐	☐	☐	☐
23. Strong muscles are important in the protection against injury.	☐	☐	☐	☐	☐
24. The majority of other players wear shin-pads during training.	☐	☐	☐	☐	☐
25. If you do not undertake the following activities indicate all the reasons why not.					
- <i>strength training at least once per week</i>					
- <i>flexibility training at least once per week</i>					
- <i>warm-ups always before training and matches</i>					
- <i>cool-downs always after training and matches</i>					

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	strength training	flexibility training	training	warm-ups	matches	training	cool-downs	matches
n/a	☐	☐	☐		☐	☐		☐
a. not enough time	☐	☐	☐		☐	☐		☐
b. too tired after training/matches	☐	☐	☐		☐	☐		☐
c. are not told to do it	☐	☐	☐		☐	☐		☐
d. are not given advice on techniques	☐	☐	☐		☐	☐		☐
e. do not believe it is necessary	☐	☐	☐		☐	☐		☐
f. nobody else does it	☐	☐	☐		☐	☐		☐

26. Are you encouraged to wear shin-pads during training?

yes ☐

no ☐

27. Are you given any nutritional advice on what to eat:

- i. *before training:*
- ii. *after training:*
- iii. *before matches:*
- iv. *after matches:*

a lot ☐
a lot ☐
a lot ☐
a lot ☐

a little ☐
a little ☐
a little ☐
a little ☐

none ☐
none ☐
none ☐
none ☐

28. Rank the following injury mechanisms from 1-10, and injury locations from 1-11, for both the likelihood of receiving an injury and severity of injury separately, 1 being the most likely and the most severe.

a. mechanisms	i. likelihood	ii. severity.
tackling	—	—
tackled	—	—
running	—	—
shooting	—	—
jumping	—	—
landing	—	—
heading	—	—
turning	—	—
collision	—	—
overuse	—	—

29. Any other comments concerning football and injuries.

b. locations	i. likelihood	ii. severity
head	—	—
upper extremity	—	—
trunk	—	—
groin	—	—
quadriceps	—	—
hamstrings	—	—
knee	—	—
shin	—	—
calf	—	—
ankle	—	—
foot	—	—