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INJURIES IN ELITE CANADIAN WOMEN'S FIELD HOCKEY

by

Khatija L. Westbrook

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**.

Faculty of **Physical Education and Recreation**

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Injuries in Elite Canadian Women's Field Hockey** submitted by **Khatija L. Westbrook** in partial fulfillment of the requirements for the degree of **Master of Science**.

Dr. Dru Marshall

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Date Submitted April 11, 2000

ABSTRACT

A prospective cohort study was undertaken to ascertain the patterns and nature of injuries and the extrinsic risk factors associated with these injuries that occurred during the Canadian women's national field hockey team's preparation for the 1999 Pan American Games. Chronic injuries caused by overuse, including fatigue, cramps and non-specific joint trauma, muscle strains, tendinitis and postural mechanical dysfunction, occurred most frequently during skill training in practices. Acute injuries caused by contact and mechanical stress, such as contusions, sprains and traumatic mechanical dysfunction, occurred more frequently in games than in practices, and more frequently in the second half. The majority of injuries were of moderate severity. The lack of effect of extrinsic risk factors on injury and the theoretical basis for the causes of chronic and mechanical stress injury suggest that future research should be directed toward intrinsic causes of injury.

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CHAPTER 1

Introduction

1.1 Introduction

Safe participation and performance enhancement are the cornerstones of sports medicine. Information regarding the incidence and severity of injuries and risk factors leading to injuries provides important information to enhance both safety in training and competition and athletic success.

Field hockey has the potential for many injuries. Serious injuries can include a loss of vision caused by a blow to the eye by a ball or stick and brain damage caused by a blow to the head by a stick, ball, or another player (Moore, 1987). Because of this injury potential, coaches need access to injury statistics in order to be aware of potentially dangerous situations and, consequently, to create safe training environments.

Coaches at the elite level strive to develop athletes and teams that are successful internationally. At the highest levels of competition, such as the Olympic Games, success is measured by performance. At this level of athletic involvement, small changes in physical characteristics of an athlete can translate into large changes in physical performance. Injuries can create changes in the physical characteristics of an athlete. Some athletes will not be able to participate at all following an injury. Other athletes, while able to participate, may not be able to generate the full force, power, or range of motion that is required to be successful. When competing for international prowess, the physical differences between participants can be miniscule. Consequently, any advantage an athlete can have physically may translate to a huge competitive advantage. Preventing injury, thus preserving the athlete's ability to perform, can be considered a competitive advantage. Injury statistics that provide information regarding the risk factors of injury allow therapists and coaches to prepare athletes for the physical rigors of the sport.

Unfortunately, there are few studies which describe in depth the incidence and severity of injuries occurring in field hockey (Fox, 1981; Jamison & Lee, 1989). Studies that do exist describe university competition or competition only at tournaments, but not national team training and competition. The Canadian women's national field hockey team has been involved in centralized training since the late 1980's. Centralized training refers to a situation where all athletes from one team train in one location for a period of weeks or months. During the period of centralization, technical, tactical and conditioning training is closely monitored by the coaches and therapists. When the centralization ends, athletes return to their home cities and continue to train in a less controlled environment. Because this team has chosen to train in a centralized fashion, and in order to provide a safe training environment and to preserve the athlete's ability to physically perform, it is important to have an understanding of the patterns of injuries that might occur. However, there are no studies that document injury rates or risk factors during these periods. There are also no injury studies for other Canadian national team sports that train in a centralized fashion, such as men's and women's volleyball and women's ice hockey. While anecdotal experience by the medical staff involved with the national field hockey team recognized patterns of injuries occurring from year to year, there has been no formal documentation.

1.2 Purpose

The prevention of sports injuries is a complex problem and a continuing challenge to sports medicine (Lysens et al., 1984). Continuous data are needed in order to observe specific trends, to implement in depth investigations and to carry out preventive measures (Finch, 1997). Because very little information exists regarding injuries in field hockey, the development of preventive measures for this sport is very difficult.

Collection of injury data is also a complex process. While injury trends in many sports have been studied, there are still issues regarding the definitions of the nature and severity of injury and the methods of data collection. Standardized data collection methodologies, including definitions, would do much to improve the comparability and interpretation of published data (Finch, 1997). In an attempt to provide some standardization in data collection of sports injuries, Meeuwisse and Love (1998) developed the Canadian Intercollegiate Sport Injury Registry (CISIR). This injury reporting system was originally designed for football, but was structured to allow expansion to other sports (Meeuwisse & Love).

The purpose of this study was to perform an in-depth injury study of elite women's field hockey in Canada using an adaptation of the CISIR. Injuries that occurred during the centralized training of the Canadian women's national field hockey team from April 26, 1999 to the end of the Pan American Games in August, 1999 were recorded. Data from this study identified both the pattern and nature of injuries that occurred and the extrinsic risk factors associated with these injuries. Extrinsic risk factors are factors outside the body that influence the occurrence of an injury (Taimela, Kujala, & Osterman, 1990). Data analyses indicated where preventive measures might be required to reduce the incidence of injury. This study also identified directions for future research.

1.3 Benefits

Providing information regarding the types, severity, and patterns of injuries occurring during a period of centralized training and identifying extrinsic risk factors associated with these injuries represents the first step in injury prevention (Van Mechelen, Hlobil & Kemper, 1987 & 1992, as cited in Van Mechelen, 1997b). This first step, establishing the extent of the injury problem, provides a number of benefits.

Firstly, the identification of injuries, their patterns and their associated risk factors provides the basis for preventive changes in training methods for the next period of centralization for the national team. For example, field hockey medical staff have noted that overuse injuries, injuries related to microtrauma to tissue over time, are exacerbated with a change of training surface. The documentation of such a trend would justify a modification of the intensity of practices during the first few days of training following a change of surface.

Secondly, the study also benefits university, provincial and recreational levels of field hockey. Because national teams are vying for international supremacy, their playing techniques and training methods are considered to be on the "cutting edge". Coaches at lower levels of expertise often model their training methods on the national team. Consequently, information provided regarding the types and risks of injury for the national team could benefit the coaches at lower levels.

Thirdly, this study will provide direction for future research regarding the prevention of injuries in elite field hockey. Areas of risk that are identified can be studied in further depth and the adapted CISIR format can provide a tool for evaluation of preventive measures.

Fourthly, the adaptations made to CISIR for evaluating a prolonged period of centralized training may serve as a template for other centralizing national teams wishing to study injury patterns in their particular sport.

1.4 Delimitations

The study collected specific information regarding injuries that occurred during the centralized training of the Canadian women's national field hockey squad. This squad represented the top female field hockey players in Canada and, consequently, was considered to be a population, not a sample. The centralization was divided into sections during which there were varying numbers of participants. Each period included a combination of practices and international competitions.

The study identified the patterns and nature of injuries that occurred during the different sections of centralization. The study collected data on both injured and uninjured athletes. Incidence was reported as the number of injuries per hour of exposure time. Exposure information differentiated between partial and complete participation. If an athlete was unable to participate fully, the reason for her decreased participation was recorded.

The study identified extrinsic risk factors (factors outside the body) that might have increased the risk of injury. These extrinsic risk factors included individual exposure time (participation), type of activity, cause of injury, history of injury, weather conditions, equipment, and the use of tape or bracing. The study did not assign causation but rather identified factors that may have influenced injury rates.

1.5 Limitations

A number of limitations existed within this study. Firstly, the population size was small. It ranged from 16 to 24 athletes. This size made calculations of significance less reliable as numbers of at least 30 are generally accepted as most reliable (Currier, 1990). To combat this problem, incidence rates and correlations between risk factors and injuries were based on exposure time rather than on the number of athletes. This method is useful for offering a rate which can be compared between teams of different lengths of season or differing numbers of athletes (Meeuwisse & Love, 1997).

Secondly, few injury reporting systems will be able to capture all the injuries which may occur (Meeuwisse & Love, 1997; Van Mechelen, 1997). The definition of injury plays a role in this missed data. For example, a definition of sports injury based on the need for physician assessment would be biased towards a large proportion of serious, mostly acute injuries (Finch, 1997). If this type of definition was used, injuries that were treated by a therapist only, or self-treated by the injured athlete, would be excluded from the study. Consequently, this type of definition would introduce a directional under-reporting bias into the study (Finch).

Cohort studies allow the researcher to estimate under-reporting based on the definition of injury (Meeuwisse & Love, 1997). The present study on the women's national field hockey team used a reporting threshold of injury as described by Meeuwisse and Love (1998). This threshold was defined as any injury requiring the assessment and treatment by the team therapist (Meeuwisse & Love, 1998). While using this threshold allowed a much greater range of injuries to be reported than would a definition based on the need for physician assessment only, it still did not capture all injuries. Injuries such as bruises, abrasions, and blisters that were treated by the athlete, or injuries the athlete did not recognize or choose to reveal, still went unreported (Wallace & Clark, 1988).

Thirdly, a physician did not, in many cases, confirm the specific diagnosis of injury unless there was a need for diagnostic testing that was outside of the scope of practice of the therapist (e.g., x-rays, blood tests, and magnetic resonance imaging [MRI]). Confirmation of injury diagnosis decreases the potential for misdiagnosis. The women's national team doctor was located in Vancouver and did not travel with the team. When the team was in Vancouver, the team doctor often had contact with the athletes only once every two weeks. For periods of training and competition in locations outside of Vancouver, such as Holland and Winnipeg, he was not accessible. However, for those athletes the doctor did see, the doctor's diagnosis confirmed that of the therapist. In the absence of a confirming diagnosis by a physician, the level of expertise of the therapist becomes important in reducing the potential for misdiagnosis. Therapists with greater experience have better knowledge in current medical language, assessment techniques, indications of severity, treatment protocols, and criteria for return to play than their less experienced counterparts (Prager, Fitton, Cahill, & Olson, 1989). They are also more experienced in providing assessments with high inter-rater reliability (i.e., the same diagnosis of the same injury by different therapists) (Prager et al.). Consequently, therapists with a high level of expertise are less likely to misdiagnose an injury. The researcher for this study was also the therapist for the national women's field hockey team and had worked with the national field hockey program for 10 years. The researcher had 11 years of sport medicine experience and a significant amount of specialized training in therapeutic techniques. The potential for misdiagnosis, while always present, was minimized by the researcher's level of expertise.

Fourthly, as described above, the physiotherapist for the national team and the researcher were the same person. Financial restraints did not allow a separate therapist to be hired to monitor the injuries. As the therapist/researcher provided the diagnoses which were recorded for the study, there was potential that the therapist/researcher might have directed the diagnoses to meet desired results. However, the data were not analyzed until the completion of the study, and it was impossible for the therapist/researcher to recognize patterns of injuries different from those she was already aware of through anecdotal experience.

Fifthly, this study did not investigate intrinsic risks of injury. According to Meeuwisse's (1994) model of multifactorial etiology in athletic injury, intrinsic risk factors (individual biological and psychosocial characteristics) create an athlete predisposed to injury. This athlete, when exposed to extrinsic risk factors, becomes more susceptible to injury. With an inciting event, an injury occurs (Meeuwisse). The exclusion of intrinsic risk factors may have a confounding effect on the identification of extrinsic risk factors associated with injury. However, Meeuwisse and Love (1998) acknowledged that when beginning to use a new injury reporting system, mostly extrinsic factors would be assessed. Once refined, this new system could be used to assess intrinsic factors in a directed fashion with appropriate control for confounding or modifying factors (Meeuwisse & Love). As this study represented the first time the CISIR format was used to document injuries with the national team, only extrinsic factors were assessed.

Finally, this study involved a very specialized population. As such, generalizability to other groups was decreased.

1.6 Definitions

One of the difficulties when performing injury studies is that there is no universally accepted definition of what constitutes an injury (Finch, 1997; Loes, 1997; Prager et al., 1989). Prager et al. defined injury as an event causing a time loss of 48 hours after injury. Time loss was defined as the inability of the player to return to practice or to the field of play. Collins, Wagner, Peterson and Storey (1989) defined injury as any musculoskeletal ailment that caused the athlete to stop training for at least one day, reduce mileage, take medicine, or seek medical care. The difference in these definitions makes comparisons between the two studies difficult. This lack of comparability between studies led Meeuwisse and Love (1998) to employ a reporting threshold for data collection rather than a specific definition. With this system, a precise injury definition is not applied at the time of data collection. Instead, the definition is applied to the data after it is collected. The advantage of defining injury after data collection is that the definition can be tailored to match the results of other data, increasing the potential to compare the results (Meeuwisse & Love, 1997). As the present study used an adaptation of Meeuwisse and Love's CISIR format (1998), it also used the CISIR reporting threshold. This threshold was defined as any injury that led to an assessment and treatment by the team therapist (Meeuwisse & Love, 1998). It did not capture medical conditions, such as amenorrhea, or injuries that were unreported by the athlete. Because this study was designed to capture as many injuries as possible, the definition of injury assigned after data collection remained the same as the pre-data collection reporting threshold – that is, an injury was defined as any condition that led to an assessment or treatment by the team therapist.

For reporting purposes, injuries were categorized as acute and chronic. Acute injury was defined as tissue disruption resulting from the application of some external force (Meeuwisse, 1994; Taimela et al., 1990). Chronic injury was defined as tissue disruption that occurred from repetitive mechanical overload which exceeded the tissue's ability to regenerate (Meeuwisse; Taimela et al.).

The definition of severity of injury raises similar problems as the definition of injury itself. There is no universal definition (Finch, 1997; Loes, 1997; Prager et al., 1989). Most injury reporting systems use a time loss definition. Using this definition, however, fails to capture the less serious injuries such as lacerations and mild concussions where there is no time lost from participation (Meeuwise & Love, 1997). Most studies also do not differentiate between partial and complete participation (Meeuwisse & Love). Consequently, incidence of injury is missed when a person participates in some, but not all, aspects of the activity. As most athletes return to full activity gradually when recovering from an injury, the lack of differentiation between partial and full participation affects the estimation of injury severity (Meeuwisse & Love). Documentation of degrees of participation better represent an elite athletic population. This study addressed these issues by defining severity on a scale characterized by both medical and participation factors. This five-point ordinal scale is outlined below. Not every characteristic in each category had to be present for the injury to be classified in that category. If the injury had characteristics in more than one category, the more severe category was used.

Mild:

No formal treatment required.
Taping, bracing or pre-practice/game stretching may be necessary.
Full participation (greater than 75% of quantity of activity).

Mild – Moderate:

Minimal treatment required (once per week or less; home exercise program).
Full participation with/with out restricted activity or partial participation (25% to 75%) for one practice only or for one game only.

Moderate:

Treatment required greater than once per week.
Referral to physician for diagnostic testing such as x-rays or bone scans.
Medication prescribed.
Skin closure or stitches following laceration.
Partial participation for more than one practice or for more than one game.
Minimal participation (25% or less) for more than one practice.
No participation for one practice only or for one game only.

Moderate – Severe:

Treatment required as per moderate.
Medication prescribed.
Medical follow-up with a specialist or diagnostic tests such as magnetic resonance imaging (MRI) or CT Scan.
Minimal Participation (25% or less) for more than one practice.
No participation for more than one practice or more than one game.

Severe:

Surgery or hospitalization.
End of training or competition.
End of athletic career.

The definition above was used for reporting purposes rather than as a delimitation for the study.

Frequency of injury was defined as the number of injuries which occurred (Loes, 1997). Using frequency alone when reporting injury data, however, does not allow for easy comparison among teams with different lengths of season or among different sports as does a rate of the number of injuries to time (Finch, 1997; Loes, 1997; Meeuwisse & Love, 1997). This rate is termed incidence. Due to the fluctuating number of participants in each phase of the centralization, this study used both incidence and frequency. Incidence was defined as the number of injuries per hour of exposure.

1.7 Summary

The prevention of injury allows for both safe participation and successful performance for any athlete. Field hockey is a potentially dangerous sport that has no injury data for participants at the elite level. This study sought to collect information on the patterns and nature of injuries and their associated extrinsic risk factors for members of the Canadian women's national field hockey team using an adaptation of an existing and validated injury reporting system.

1.8 References

Collins, K., Wagner, M., Peterson, K. & Storey, M. (1989). Overuse injuries in Triathletes: A study of the 1986 Seafair Triathlon. The American Journal of Sports Medicine, 17(5), 675 – 680.

Currier, D. (1990). Elements of Research in Physical Therapy. Baltimore: Williams and Wilkins.

Finch, C. (1997). An overview of some definitional issues for sports injury surveillance. Sports Medicine, 24(3), 157 – 163.

Fox, N. (1981) Risks in field hockey. In T. Reilly (Ed.), Sports Fitness and Sports Injuries, Boston: Faber and Faber, 112 – 117.

Jamison, S. and Lee, C. (1989). The incidence of female hockey injuries on grass and synthetic playing surfaces. The Australian Journal of Science and Medicine in Sport, June, 15 – 17.

Loes, M. (1997). Exposure data: Why are they needed? Sports Medicine, 24(3), 172 – 175.

Lysens, R., Severlynck, A., van den Auweele, Y., Lefeurs, J., Renson, L., Claessens, A. and Ostyn, M. (1984). The predicatability of sports injuries. Sports Medicine, 1(1), 6 – 10.

Meeuwisse, W. (1994). Assessing causation in sport injury: A multifactoral model. Clinical Journal of Sports Medicine, 4(3), 166 – 170.

Meeuwisse, W. and Love, E. (1997). Athletic injury reporting: development of universal systems. Sports Medicine, 24(3), 184 – 204.

Meeuwisse, W. and Love, E. (1998). Development, implementation and validation of the Canadian intercollegiate sport injury registry. Clinical Journal of Sport Medicine, 8(3), 164 – 177.

Moore, S. (1987). Field hockey. In, S. Abrams, M. Adrian, and M. Bayless (Eds.), Catastrophic injury: Surveillance and reporting, Indianapolis: Benchmark Press, 67 – 76.

Prager, B., Fitton, W., Cahill, B. & Olson, G. (1989). High school football injuries: A prospective study and pitfalls of data collection. The American Journal of Sports Medicine, 17(5), 681 – 685.

Taimela, S., Kujala, U. & Osterman, K. (1990). Intrinsic risk factors and athletic injuries. Sports Medicine, 9(4), 205 – 215.

Van Mechelen, W. (1997). The severity of sports injuries. Sports Medicine, 24(3), 176 – 180.

Van Mechelen, W. (1997b). Sports injury surveillance systems 'one size fits all?' Sports Medicine, 24(3), 164 – 168.

Wallace, R. & Clark, W. (1988). The numerator, denominator and the population at risk. American Journal of Sports Medicine, 16(suppl. 1), S55 – S56.

CHAPTER 2

Review of Literature

2.1 Introduction

Prevention of injury is an important aspect of sport medicine. In order to create a preventive program, however, the extent of a sport's injuries must be known. Very little information exists regarding injuries in field hockey.

In an attempt to amass more information on injuries in field hockey, a study was conducted with the Canadian women's national field hockey team during its preparation for the 1999 Pan American Games. Information was collected regarding the patterns and nature of injuries and on the extrinsic factors that affected these injuries.

The following section describes the information that currently exists with respect to injuries in field hockey, the difficulties encountered when studying injury trends in sport and the considerations needed to conduct an injury study.

2.2 Review of Literature

Sports injury data are important for a number of reasons (Finch, 1997). Firstly, they provide a guide for sports injury prevention. Secondly, they assist in the identification of priority areas for injury prevention research. Thirdly, they can be used to evaluate the effectiveness of interventions (Finch). Sports injuries result from a complex interaction of identifiable risk factors at a given point in time (Lysens et al., 1984). Information gathered regarding the nature of injuries and their risk factors could form the basis of sports injury prevention training programs and the planning of resources needed to treat and manage the injuries (Finch).

2.2.1 Injuries in field hockey.

Compared to sports such as football, hockey and baseball, there are few studies on injuries in field hockey (Fox, 1981; Jamison & Lee, 1989). Most of the studies that do exist lack in-depth injury analyses. Rose (1981) performed an observational study over a four-year period, from 1976 to 1979, of injuries sustained in women's field hockey at California State University. A major injury was defined as an injury that required the attention of a team physician and produced definite disability needing follow-up care. A minor injury was defined as an injury requiring the attention of the team physician in some cases, but was managed predominantly by the trainer and produced no or limited disability. Neither of these definitions considered the degree of participation. Rose (1981) classified injuries into two groups – (a) injuries due to direct trauma (such as being hit with a stick or ball, player to player contact, and falls) and (b) acute or chronic injuries associated with internal stress. Results were described by frequency only. The majority of injuries occurred to the lower extremity followed by injuries to the head and face. Few injuries occurred to the upper extremities. Rose concluded that while most injuries in field hockey were minor, the major injuries that occurred were serious enough to reveal a hazard in the sport.

Whitney (1983) studied the injuries sustained by the British women's national team during the 1979 World Cup. Whitney noted player position, diagnosis, mechanism of injury and the treatment of the injury. There was no discussion of research methods and no mention of amount of exposure per participant or of any environmental or training factors that may have been involved in these injuries. Whitney offered no definition of injury or severity and provided no statistical analysis. Rather, the injuries were simply listed. If the reader performs some calculations, the following results can be found. A total of 18 injuries were documented during the 1979 World Cup. Twelve injuries were to the lower extremity, three were to the face, two were to the upper extremity, and one was to the neck. Two medical conditions, heat stroke and double vision, were also noted. The distribution of injuries among player positions included one injury for the goaltenders, five for the defenders, five for the midfielders and nine for the forwards. The mechanisms of injury were related to surface conditions in five injuries, to contact by ball, stick, ground or body in nine injuries, and to overuse in six injuries.

Jamison and Lee (1989) performed a prospective study of the injuries that occurred during the 1984 and 1985 Australian National Women's Hockey Championships. The purpose was to investigate the difference in injuries between championships played on grass versus those played on artificial turf. The researchers collected baseline data on injury status prior to each competition and information on each injury including type, location and mechanism of injury, position on the field, footwear and weather conditions. They found that lower limbs were injured most frequently regardless of playing surface and that players on artificial turf were at slightly greater risk of injuring the body, head and arms and at lower risk of injuring lower limb joints. They also identified extrinsic and intrinsic causes of injury. Extrinsic causes included impact of the ball or stick, collision with another player, and a fall. Intrinsic causes included internal strains upon the body. Incidence was calculated as number of injuries per participant and z-tests were performed to compare the differences of the injuries on different surfaces.

Lee-Knight, Harrison and Price (1992) studied the number of dental injuries that occurred at the 1989 Canada Games. Again, the experimental design was not discussed and the amount of exposure per participant was not determined. Of the total number of female field hockey players participating in the Games, 1.3% suffered dental injuries. None of the players who were injured wore mouth guards.

2.2.2 Difficulties associated with sport injury studies.

The studies described in the previous section illustrate many of the problems inherent in injury studies. Data used in assessing injury trends often come from widely varying reporting systems, introduce many sources of errors and make comparison of data across the literature difficult (Meeuwisse & Love, 1997). Comparability of studies is compromised by a lack of standardized methodology of data collection and standardized definitions of injury and severity of injury (Finch, 1997; Loes, 1997; Prager, Fitton, Cahill and Olson, 1989).

The first step in injury prevention is to establish the extent of the injury problem (Van Mechelen, Hlobil & Kemper, 1987 & 1992, as cited in Van Mechelen, 1997). If the data collected from sports injury research on field hockey are to form the basis of injury prevention, focused field studies that document specific characteristics not included in the studies above need to be conducted (Wallace, 1988). Firstly, in order to properly document incidence of injury, both injured and uninjured athletes need to be included in the study (Loes, 1997). The Jamison and Lee (1989) and Lee-Knight et al. (1992) studies were the only studies cited above that included all the athletes at risk of injury.

Secondly, the most desirable level of injury data is that in which the athlete's time at risk is also considered (Loes, 1997). The inclusion of the duration and frequency of training and competition changes a simple frequency into incidence (Loes, 1997). The use of incidence allows for comparability among studies (Finch, 1997). None of the studies cited above included incidence.

Thirdly, the athlete's individual characteristics, such as the player's position, and the specific nature of the injury must also be measured (Meeuwisse & Love, 1998). However, as illustrated above, few studies document these characteristics in detail (Meeuwisse & Love). When conducting injury studies, the researcher needs to include the activity the athlete was involved in at the time of injury, the position the athlete was playing, the location on the field where the injury occurred, and the mechanism, nature and the severity of the injury (Finch, 1997). The Jamison and Lee (1989) study was the only study that included some of this information. The study did not, however, analyze all of the information collected.

Fourthly, risk factors that might predispose an athlete to injury need to be considered. Sports injury results from an interaction of intrinsic and extrinsic risk factors (Lysens et al., 1984; Meeuwisse, 1994; Taimela, Kujala and Osterman, 1990). Intrinsic factors are individual biological and psychosocial characteristics predisposing a person to an injury (Lysens et al.; Meeuwisse; Taimela et al.). They include maturational stage, joint flexibility and laxity, somatotype, muscle imbalance, biomechanics, conditioning, and personality traits (Lysens et al.; Meeuwisse; Meeuwisse & Love, 1998). Extrinsic factors are independent of the injured person and are principally related to the type of activity during the time of injury (Taimela et al., 1990). They include weather, equipment, type of activity, history of injury, individual exposure time, field surface type and condition, and type of injury (Lysens et al.; Meeuwisse; Meeuwisse & Love, 1998; Van Mechelen, 1997).

Studies of injuries in field hockey have only analyzed extrinsic factors in a limited fashion. Rose (1981), Whitney (1983), Jamison and Lee (1989), and Lee-Knight et al. (1992) documented the mechanisms of injury such as contact by a stick, ball, another player or the ground, and overuse. The Whitney study also included player position. None of these studies investigated the correlation of these factors to the incidence of injury.

2.2.3 Considerations for conducting an injury study.

An injury prevention program must first start with an assessment of the nature of injuries and the factors that influence these injuries. The studies on field hockey outlined previously do not fully provide this information. A clear picture of injuries within a sport is best attained through a prospective cohort study design (Meeuwisse & Love, 1997; Van Mechelen, 1997; Walter, Sutton, McIntosh and Connolly, 1985). This type of study involves enrolling a group of athletes (a cohort) at the beginning of the study and following them forward in time. A cohort design allows the researcher to examine characteristics which differ between injured and uninjured groups of athletes, to measure injury rates, to estimate injury risk, to measure varying amounts of participation for each athlete and to assess the completeness of reporting (Meeuwisse & Love).

The Canadian Intercollegiate Sport Injury Registry (CISIR), validated by Meeuwisse and Love (1998), is a tool created for use in prospective observational cohort study designs. The purpose of the CISIR is to extract information on the rates and risks of injury (Meeuwisse & Love). Rate of injury is determined through the collection of data on each athlete's participation. The data are sorted by player position and by regions of injury, and this information is linked to environmental factors (Meeuwisse & Love). CISIR collects preparticipation (preseason), exposure (participation), and injury information (Meeuwisse & Love).

The preparticipation assessment employs a standardized medical form to collect baseline information on the demographic characteristics of the study participants, injury risk factors and the use of preventive equipment (Meeuwisse & Love, 1997). The questions revolve around the potential risk factors in the particular sport (Meeuwisse & Love, 1998). The advantage of the preparticipation assessment is that it allows for risk factor information to be collected for all athletes, not just the injured ones (Meeuwisse & Love, 1998). The amount of time an athlete is exposed to activity is collected through a weekly exposure sheet (WES) (Meeuwisse & Love, 1998). This form documents each athlete's amount of participation for each game and practice session and states the reason for partial or no participation (Meeuwisse & Love, 1997). The information gathered through the WES can be used as the denominator for incidence rates. Specific information regarding each injury is captured by the use of an individual injury report form (IIRF) (Meeuwisse & Love, 1998).

The CISIR format is particularly suited for use with the Canadian women's national field hockey team for three reasons. Firstly, Meeuwisse and Love (1998) chose to base their injury registry on intercollegiate athletes because this group represented a well-defined, homogeneous population that trained and competed in a structured fashion with a predetermined beginning and end to their seasons and with a coordinated health care system. The national team fits these criteria perfectly and may even be considered a more homogeneous group than intercollegiate athletes. National team athletes follow the same training program throughout an entire year and participate in very structured practice and training schedules. As in the university setting, the health care staff is available for consultation throughout the entire year. Secondly, the ideal situation for an injury study is one where a full-time therapist is available on a daily basis to consistently document detailed participation and injury data (Meeuwisse & Love; Prager et al., 1989). During centralized training, the therapist for the national team attends all training events and competitions. Thirdly, a prospective observational cohort study could use an existing sports injury surveillance system as long as this system was tailored to the specific sport situation (Van Mechelen, 1997). CISIR, although originally designed for football, was structured to allow for adaptation to other sports (Meeuwisse & Love).

In order to make CISIR specific to field hockey, the characteristics of the sport and risks associated with injury need to be incorporated into the monitoring system. Field hockey is a fast moving field game (Fox, 1981). Good running, readiness for explosive action, fast visual reactions and the ability to handle the stick skillfully and efficiently are essential requirements for any player (Fox, 1981). Unique to field hockey, however, is that these skills must be performed in a semi-crouched position (Fenety & Kumar, 1992; Lindgren & Twomey, 1988; Reilly & Seaton, 1990). Field hockey players increase the muscle work and spinal loading by running for most of the 70 minute game or two hour practice in varying degrees of trunk flexion (Lindgren & Twomey, 1988). Athletes are exposed to various injuries to many body parts during sustained forward trunk flexion, running, turning, twisting, stretching, and awkward falling (Fenety &

Kumar; Fox; Lindgren & Twomey). Although field hockey is a "non-contact" sport, numerous injuries occur from contact with a stick, ball, another player or the ground (Fox; Jamison & Lee, 1989; Lee-Knight et al., 1992; Rose, 1981; Whitney, 1983).

The field hockey athlete is at risk of injury in a number of situations (Fox, 1981). Tackling refers to face to face confrontations where the defending player is attempting to take the ball from the opposing player. Many injuries can occur when players are in close proximity, including lacerations, abrasions and bruises to the face, hands, forearms, knees, shins and ankles. Set plays involve the propulsion of the ball through large number of players. Free hits, awarded for infractions of the rules within the field, and sideline hits, awarded when the ball goes out of bounds, are the most frequently recurring plays. In these plays, offenders and defenders form a ring around the ball and the ball is hit through the players. The speed of the ball and the proximity of the players combined with the frequency of these set plays make this aspect of the game particularly dangerous. Penalty corners represent the most dangerous situation in the game. The penalty corner is awarded for infractions by the defending team within the striking circle (a semicircle around the net with a radius of 14.6 m). The offensive players stand on the outside of this circle and five defensive players stand behind the end line. One offensive player stands behind the end line and passes the ball to the players at the top of the circle. An offensive player at the top of the circle strikes the ball at the net while the defending players attempt to prevent a goal being scored. A corner is similar to that awarded in soccer. All the players in these set pieces must make quick decisions. The defenders have little time to assess the situation and take action and the offenders rush the net to deflect the shot or collect the rebounds. These characteristics demonstrate that the adapted CISIR format will have to include categories of acute and chronic injury resulting from a number of causes.

Fox (1981) also described extrinsic factors that might be associated with injury in field hockey. Because play is most intense near the circle, the forwards, defenders and goalies might be at greater risk of injury than midfielders. International field hockey is played on wet artificial turf but hot weather conditions can cause the field to dry. Conditions of the playing surface might have a significant effect on injury occurrence. Weather could also play a role in injury occurrence. Inclement or very bright conditions could decrease visibility. Apart from the goalie, players wear very little equipment. Injuries might be preventable if more equipment was worn (Fox, 1981). The adapted CISIR format will have to include methods to document these risk factors.

2.3 Summary

Sports injury data provide the basis for injury prevention. Establishing the extent of injuries is the first step of this prevention program. Unfortunately, there are few studies that describe injuries in field hockey. Most of the studies that do exist lack an in depth analysis. Data on injuries should incorporate both injured and uninjured athletes and should include a measure of exposure, the specific characteristics of the injury and extrinsic risk factors associated with the injury. A prospective observational cohort design is best suited to capture these details. CISIR is a data collection tool created for this type of design. When adapted to include the specific risk factors associated with field hockey, this format could be used to study the incidence and severity of injuries occurring during a centralized training period of the Canadian women's national field hockey team.

2.4 References

Fenety, A. & Kumar, S. (1992). Isokinetic trunk strength and lumbosacral range of motion in elite women field hockey players reporting low back pain. Journal of Orthopaedic and Sports Physical Therapy, 16(3), 129 – 135.

Finch, C. (1997). An overview of some definitional issues for sports injury surveillance. Sports Medicine, 24(3), 157 – 163.

Fox, N. (1981) Risks in field hockey. In T. Reilly (Ed.), Sports Fitness and Sports Injuries, Boston: Faber and Faber, 112 – 117.

Jamison, S. and Lee, C. (1989). The incidence of female hockey injuries on grass and synthetic playing surfaces. The Australian Journal of Science and Medicine in Sport, June, 15 – 17.

Lee-Knight, T., Harrison, E. & Price, C. (1992). Dental injuries at the 1989 Canada games: An epidemiological study. Journal of the Canadian Dental Association, 58(10), 810 – 815.

Lindgren, S. & Twomey, L. (1988). Spinal mobility and trunk muscle strength in elite hockey players. The Australian Journal of Physiotherapy, 34(3), 123 – 130.

Loes, M. (1997). Exposure data: Why are they needed? Sports Medicine, 24(3), 172 – 175.

Lysens, R., Severlynck, A., van den Auweele, Y., Lefeurs, J., Renson, L., Claessens, A. and Ostyn, M. (1984). The predictability of sports injuries. Sports Medicine, 1(1), 6 – 10.

Meeuwisse, W. (1994). Assessing causation in sport injury: A multifactorial model. Clinical Journal of Sports Medicine, 4(3), 166 – 170.

Meeuwisse, W. and Love, E. (1997). Athletic injury reporting: development of universal systems. Sports Medicine, 24(3), 184 – 204.

Meeuwisse, W. and Love, E. (1998). Development, implementation and validation of the Canadian intercollegiate sport injury registry. Clinical Journal of Sport Medicine, 8(3), 164 – 177.

Prager, B., Fitton, W., Cahill, B. & Olson, G. (1989). High school football injuries: A prospective study and pitfalls of data collection. The American Journal of Sports Medicine, 17(5), 681 – 685.

Reilly, T. & Seaton, A. (1990). Physiological strain unique to field hockey. The Journal of Sports Medicine and Physical Fitness, 30(2), 142 – 146.

Rose, C. (1981). Injuries in women's field hockey: A four year study. The Physician and Sports Medicine, 9(3), 97 – 100.

Taimela, S., Kujala, U. & Osterman, K. (1990). Intrinsic risk factors and athletic injuries. Sports Medicine, 9(4), 205 – 215.

Van Mechelen, W. (1997). Sports injury surveillance systems 'one size fits all?' Sports Medicine, 24(3), 164 – 168.

Wallace, R. (1988). Application of epidemiologic principles to sports injury research. American Journal os Sports Medicine, 16(suppl. 1), S22 – S24.

Walter, S., Sutton, J., McIntosh, J. and Connolly, C. (1985). The aetiology of sports injuries: a review of methodologies. Sports Medicine, 2, 47 – 58.

Whitney, S. (1983). World cup hockey. Physiotherapy, 69(11), 390 – 392.

CHAPTER 3

Methods

3.1 Introduction

A goal of sport medicine is to prevent injury. Sport injury data provide the guide for sports injury prevention (Finch, 1997). Unfortunately, in the sport of field hockey few in-depth injury studies exist. The lack of data on field hockey injuries makes the development of preventive measures difficult. In response to this lack of data, an injury study was conducted on the Canadian women's national field hockey team during training for the 1999 Pan American Games. This study sought to establish the extent of the injury problem in elite women's field hockey in Canada. This purpose represents the first step in injury prevention (Van Mechelen, Hlobil & Kemper, 1987, 1992 as cited in Van Mechelen, 1997).

3.2 Research Design

Data on injuries should incorporate both injured and uninjured athletes and should include a measure of exposure, the specific characteristics of the injury and the extrinsic risk factors associated with the injury (Finch, 1997; Loes, 1997; Meeuwisse and Love, 1998; Taimela, Kujala and Osterman, 1990). In order to capture these details, this study used a prospective observational cohort design. The data collection tool was an adaptation of the Canadian Intercollegiate Sport Injury Registry (CISIR) (Meeuwisse and Love). This pre-existing tool was validated by Meeuwisse and Love for an injury study on the Canada West University Athletic Association football league.

3.3 Subject Selection

Subjects included in this study were members of the Canadian women's national field hockey squad who participated in the centralized training period prior to the 1999 Pan American Games and those members who were selected from this squad to participate in the Pan American Games. The number of participants varied from 16 to 24, depending on the section of training. The particular number of athletes and the time periods and locations where the observations took place are listed in table 3.1.

Table 3.1

Dates, Location and Number of Participants for Each Section of Centralized Training.

Dates	Location	Number of participants (N)
April 26 to May 7, 1999	Vancouver	24 athletes
May 10 to May 21, 1999	Holland	17 athletes
May 31 to June 20, 1999	Vancouver	23 athletes
June 26 to July 9, 1999	Winnipeg	16 athletes
July 17 to August 8, 1999	Pan American Games - Winnipeg	16 athletes

Athletes who participated in the first section of training were selected by the Canadian women's national team coach through identification camps held across Canada from November 1998 to January 1999. These athletes, chosen on the basis of their ability in field hockey, represented the most elite population of female field hockey players in Canada. The national team coach also selected athletes from the original 24 to participate in each of the subsequent sections of training. The researcher was not involved in these selection processes.

3.4 Procedures

On the first day of practice (April 26, 1999), the study, including its risks and benefits, was described to the athletes. Participation in the study was completely voluntary and had no bearing on selection to the Pan American Games Team nor on the provision of any therapy care that was required during the course of training. Athletes were informed that they could withdraw from the study at any time without consequence. The athlete's willingness to be involved in the study was documented by a consent form (refer to Appendix A).

In order to maintain anonymity, each participant was randomly assigned a number. Any athlete names that appeared on any forms other than the consent forms were removed and replaced with this number. The researcher was the only person to know the number assignments. All completed documents were secured in a locked container and stored in the residence of the researcher.

Data were collected on each participating athlete through three methods. The first method required the athlete to complete a questionnaire on injuries sustained prior to the beginning of centralized training (refer to Appendix B). This questionnaire paid particular attention to back injuries, concussions and the use of braces or tape. The second method required the researcher to document the amount of exposure to activity for each athlete for each practice and game for the duration of the centralization, including the Pan American Games. This information was documented through an exposure sheet (refer to Appendix C). The exposure sheet also captured information for each session including a session description, field and weather conditions, field (turf) and air temperatures and humidity. The third method required the researcher to complete an injury report form for each injury brought to the attention of the researcher for the duration of the centralization, including the Pan American Games (refer to Appendix D).

These documents were adapted from the original CISIR format (refer to Appendix E), developed by Meeuwisse and Love (1998) for use with the Canada West University Athletic Association football league, to reflect the specific nature of field hockey. These adaptations were developed through review of the literature, and discussions with the head coaches of the Canadian women's junior and senior national field hockey teams, the national team physician and the physiotherapist for the women's junior national team. One change was made to the CISIR questionnaire of previous injuries. "Stingers", both anecdotally and through review of field hockey injury studies, were not found to occur frequently. Consequently, the stingers section was removed and was replaced by a section on back injury.

A number of changes were made to the CISIR exposure form. Training was added to the types of session that could be documented. Training referred to the running and weight work-outs that members of the team completed three to four times per week. Field type was removed because all international field hockey matches and, consequently, all national team practices are played on artificial turf. Potential for heat injury exists in field hockey because the game can be played in very hot weather conditions. In order to capture the extrinsic factors that could potentially affect heat injury, measurements of ambient and field level temperature, as well as humidity, were added. Ambient and field level ("turf") temperature were both recorded because anecdotal experience demonstrated that field level temperature is often higher than ambient temperature. For athletes not participating fully in practice, a minimal level of participation (less than 25%) was returned to the participation criteria. Minimal participation was originally removed from CISIR because therapists working with football felt there was no difference in their sport between minimal and partial participation (Meeuwisse and Love, 1998). In field hockey, however, there was a discernable difference. Minimal participation included stationary hitting and passing with no running and partial participation included running drills in which the athlete participated from 25 to 75 percent.

A number of changes were also made to the CISIR injury report form. A diagram of a field hockey pitch divided into zones was added. The field hockey positions of forward, midfield, defense and goalie replaced the football positions. Equipment specific to field hockey, including goalie equipment, mouth guards and shin guards was added. Specific categories for the condition of injury were added to reflect that a field hockey match consists of two halves and the potential for overtime and penalty shots (strokes). The practice and other sections were made to reflect the specific nature of the national team's training program. Categories were added to the treatment section in order to reflect the severity criteria outlined in the definitions.

Duplications of injury information existed within the questionnaire of previous injury, the exposure form, and the injury report. These duplications included the date of injury, session type, loss of exposure time and the reason for this loss, history of previous injury and mechanism of injury. These duplications provided both a means of ensuring completeness of information and a means of evaluating the ability of the adapted forms to adequately capture the injury information. For example, information on mechanism of injury was documented through check boxes and through text. If the forms were not adequate, information would appear in the text section that could not be documented in the check boxes. Consequently, the researcher was able to ascertain if new categories would need to be developed for future research.

3.5 Definitions

This study used a reporting threshold rather than a specific definition of injury. This threshold, the same threshold as the CISIR format, was defined as any injury that led to an assessment and treatment by the team therapist (Meeuwisse & Love, 1998). Because this study was designed to capture as many injuries as possible, this reporting threshold became the definition of injury during data analyses.

For reporting purposes, injuries were categorized as acute and chronic. Acute injury was defined as tissue disruption resulting from the application of some external force (Meeuwisse, 1994; Taimela et al., 1990). Chronic injury was defined as tissue disruption that occurred from repetitive mechanical overload which exceeded the tissue's ability to regenerate (Meeuwisse; Taimela et al.).

The definition of severity of injury was assigned during data analyses and was used for reporting purposes rather than delimitation for study. Severity was defined by a scale characterized by both medical and participation factors. This five-point ordinal scale is outlined below. Not every characteristic in each category had to be present for the injury to be classified in that category. If the injury had characteristics in more than one category, the more severe category was used.

Mild:

No formal treatment required.
Taping, bracing or pre-practice/game stretching may be necessary.
Full participation (greater than 75% of quantity of activity).

Mild – Moderate:

Minimal treatment required (once per week or less; home exercise program).
Full participation with/with out restricted activity or partial participation (25% to 75%) for one practice only or for one game only.

Moderate:

Treatment required greater than once per week.
Referral to physician for diagnostic testing such as x-rays or bone scans.
Medication prescribed.
Skin closure or stitches following laceration.
Partial participation for more than one practice or for more than one game.
Minimal participation (25% or less) for more than one practice.
No participation for one practice only or for one game only.

Moderate – Severe:

Treatment required as per moderate.
Medication prescribed.
Medical follow-up with a specialist or diagnostic tests such as magnetic resonance imaging (MRI) or CT Scan.
Minimal Participation (25% or less) for more than one practice.
No participation for more than one practice or for more than one game.

Severe:

Surgery or hospitalization.
End of training or competition.
End of athletic career.

A <u>new injury</u> was one that had never occurred previously. An injury was considered <u>recurrent</u> if that specific injury had occurred previously. The definition of recurrent injury was based on type of injury rather than area of injury. For example, a medial collateral ligament injury of the knee was considered recurrent only if that medial collateral ligament had been injured previously. Conversely, an anterior cruciate ligament injury to a knee with a history of a previous medial collateral ligament injury was not considered recurrent. An ongoing injury was one that the athlete had incurred prior to the centralized training and that had not resolved. Mechanical stress referred to injuries associated with a mechanism of planting, twisting or ballistic overstretching or an application of an external force. Overuse referred to injuries associated with an insidious onset. Type of injury was defined by the researcher at the time of injury assessment and was confirmed, when possible, by the Canadian national women's team physician.

Frequency of injury was defined as the number of injuries that occurred during the period of study. Incidence was defined as the number of injuries per hour of exposure.

3.6 Data Entry

Exposure hours were calculated in the following manner. The length of each practice, game and conditioning activity was recorded. For each athlete, this time was then multiplied by 100 % for full participation, by 50 % for partial participation, by 25 % for minimal participation and by 0 % for no participation. The exposure hours for each athlete for each day were then summed to give the total exposure hours. These calculations were made directly from the exposure sheets and then recalculated twice to ensure completeness of reporting. Information on injuries and their associated extrinsic factors were entered into an SPSS 8.0 (Statistical Package for the Social Sciences, Chicago, USA) spreadsheet directly from the forms. This information was then coded again and recorded on the injury forms directly. The codes on the injury forms were then compared to the computer spreadsheet and corrections were made as necessary.

3.7 Statistical Analysis

Statistical analysis included predominantly descriptive methods and employed SPSS 8.0. Nominal data were presented by frequency tables and bar graphs. Exposure hours were presented as incidence rates. Statistical analysis was predominantly descriptive. Crosstabulations were used to assess the relationship between nominal variables. Crosstabulations are tables that show the distribution of various combinations of two variables (Norusis, 1999). The chi square test of association was used to evaluate dependence between nominal variables when the expected counts of each cell were large enough to meet the assumptions of this test (Glass and Hopkins, 1996).

3.8 References

Finch, C. (1997). An overview of some definitional issues for sports injury surveillance. Sports Medicine, 24(3), 157 – 163.

Glass, G. and Hopkins, K. (1996). Statistical Methods in Education and Psychology. Toronto: Allyn and Bacon

Loes, M. (1997). Exposure data: Why are they needed? Sports Medicine, 24(3), 172 – 175.

Meeuwisse, W. (1994). Assessing causation in sport injury: A multifactoral model. Clinical Journal of Sports Medicine, 4(3), 166 – 170.

Meeuwisse, W. and Love, E. (1998). Development, implementation and validation of the Canadian intercollegiate sport injury registry. Clinical Journal of Sport Medicine, 8(3), 164 – 177.

Norusis, M. (1999). SPSS 6.1: Guide to Data Analysis. New Jersey: Prentice Hall.

Taimela, S., Kujala, U. & Osterman, K. (1990). Intrinsic risk factors and athletic injuries. Sports Medicine, 9(4), 205 – 215.

Van Mechelen, W. (1997). Sports injury surveillance systems 'one size fits all?' Sports Medicine, 24(3), 164 – 168.

CHAPTER 4

Results

4.1 Introduction

In order to attain a better understanding of the injuries that occur in field hockey, a study was undertaken on the Canadian women's national field hockey team. This study was designed to investigate the patterns and nature of injuries and the extrinsic factors associated with these injuries that occurred during the team's preparation for the 1999 Pan American Games. The study employed a prospective observational cohort design. Data were collected through an adaptation of the Canadian Intercollegiate Sport Injury Registry (CISIR) (Meeuwisse and Love, 1998).

The duration of the study was from April 26, 1999 to August 8, 1999. This training and competitive period was divided into sections that occurred in a number of locations. Training started in Vancouver from April 26 to May 7. During this period, 12 practices and 3 inter-squad games were held. A reduced squad of 17 players traveled to Holland from May 10 to May 21 for a series of five practices and six games against club teams and the Dutch junior and senior national teams. The full squad of 23 reconvened in Vancouver from May 31 to June 20 for 13 practices and a 9 game tournament, which included Canada, Ireland, Japan and the United States. While all 23 athletes participated in the practices, only 16 athletes played in each game. The final Pan American Games team, comprised of 16 athletes, then traveled to Winnipeg from June 26 to July 9 for a series of 10 practices and 5 test matches against the England under-23 team. Finally, the team returned to Winnipeg from July 17 to August 8 for the Pan American Games. This last section of training included nine practices and eight games. The sequencing of games in competition schedules prior to the Pan American Games was set to model as closely as possible the Pan American Games schedule, both in days and in time of day. The following sections present the results from this study.

4.2 Summary of Findings

Twenty-four of the 25 athletes who took part in centralized training agreed to participate in the present study. Their ages ranged from 20 to 33 years. The incidence rate of injury for the study period was 0.034 injuries per hour. During each section of centralization, there was a peak in the total injuries per day near the midpoint and a sub-peak in the total injuries per day near the beginning. The most common type of injuries were injuries due to fatigue, cramps and non-specific joint trauma, muscle strains, tendinitis, postural mechanical dysfunction and contusions. The majority of injuries were new and occurred during practices. The lower extremities were the most frequently injured areas of the body. There was no higher risk of injury to the left or right side of the body. When the injuries were divided into chronic and acute, the majority of chronic injuries occurred in practice and the majority of acute injuries occurred in games. In practice, most injuries occurred during skill training. Skill training included all technical and tactical drills. In games, more injuries occurred in the second half. Overuse was the leading cause of injury, followed by contact and mechanical stress. The majority of injuries were of moderate severity. No playing position or area of the field had a higher frequency of injury than another area. Weather conditions and temperature did not have an effect on the number of injuries that occurred. The equipment worn did not have any effect on the frequency of injuries nor on the severity of injuries. Bracing or taping at the time of injury did not affect the severity of injury.

4.3 Incidence of Injuries

A total of 109 injuries were documented. The total hours the athletes participated in each type of centralized training activity (exposure hours) was calculated as described in methods (Chapter 3). The total number of exposure hours was 3181.7. The overall incidence of injury was 0.034 injuries per hour of exposure. Of the total hours, 1724.7 hours were spent in practice, 969 hours were spent in games, and 488 hours were spent in conditioning activities.

Participants missed a total of 172.9 hours of activity. Of these missed hours, 140.6 were lost due to injury, 7.8 were lost due to sickness, and 24.5 hours were due to absence from practices or games for reasons other than injury or sickness (e.g., interview for medical school).

Table 4.1 shows the frequency of injuries through the different types of training activities during the centralization. Other referred to injuries that occurred outside of any field hockey related activity, such as a burn (refer to Table 4.2). Game included all intersquad games and games against other opposition. Conditioning referred to all cardiovascular and strengthening activities done as part of the training requirements of the team. Not applicable (n/a) was applied when athletes reported to the first day of centralization with an unresolved injury. The majority of injuries occurred during practice. Games produced the next highest number of injuries. Using the exposure hours for each of these activities, the incidence rate was 0.034 injuries/hour for practices, 0.034 injuries/hour for games and 0.0041 injuries/hour for conditioning.

Table 4.1.

Frequency of Injury for the Different Types of Activities during Centralized Training

Activity	Frequency	Percent
Other	5	4.6
Practice	58	53.2
Game	33	30.3
Conditioning	2	1.8
N/A	11	10.1
total	109	100.0

When considering incidence, it is important to note whether the injuries observed were evenly distributed amongst the athletes. Table 4.2 shows the distribution of injuries across the study participants and figure 4.1 shows the number of athletes suffering different number of injuries. The classification of chronic or acute injury was determined from the mechanism of injury and from the history of previous injury. If an injured athlete had a previous history of injury to the specific area that was injured and the mechanism of injury was due to overuse, the injury was classified as chronic. In 10 cases, a history of previous injury existed but the cause of the injury was mechanical stress or contact. For example, 6 of these 10 cases occurred from contact with the ground or another player. In order to capture the acute nature of the causes of these injuries, they were classified as acute injuries. In seven cases, the cause of injury was unknown and no classification of chronic or acute was made. Figure 4.1 shows that two athletes account for 24 of 109 (22 %) of the injuries and six athletes account for 58 of 109 (53.2 %) of the injures. Table 4.2 shows that the period of time spent in centralized training had an effect on the number of injuries that occurred. For those athletes who centralized for eight weeks or less, the average number of injuries per athlete was 0.9 while for those athletes who centralized for longer than eight weeks, the average number of injuries per athlete was 6.4.

Table 4.2.

Number of Weeks Participated in Centralized Training and Frequency of Injury for Each Study Participant

Athlete	Number of weeks of Centralization	Total Number of Injuries	Number of Chronic Injuries	Number of Acute Injuries	Unknown Cause
1	2	1	0	1	0
2	2	0	0	0	0
3	5	1	1	0	0
4	5	0	0	0	0
5	5	2	2	0	0
6	5	2	2	0	0
7	8	1	0	1	0
8	8	0	0	0	0
9	13	7	4	3	0
10	15	6	6	0	0
11	15	8	7	1	0
12	15	4	2	2	0
13	15	10	4	5	1
14	15	6	5	1	0
15	15	5	2	1	2
16	15	0	0	0	0
17	15	8	0	5	3
18	15	14	10	3	1
19	15	6	2	4	0
20	15	6	3	3	0
21	15	0	0	0	0
22	15	9	3	6	0
23	15	4	1	3	0
24	15	9	6	3	0
Total	N/A	109	60	42	7

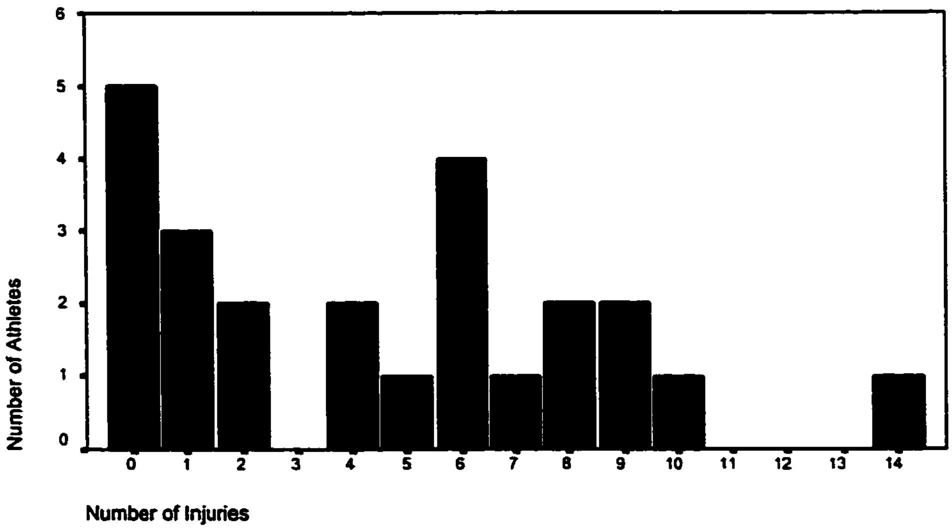

Figure 4.1. The number of athletes who suffered different numbers of injuries.

4.4 Patterns of Injury Occurrence

Figure 4.2 illustrates the number of injuries that occurred for each day of centralization, divided into game and practice injuries. The locations of each training section are also labeled. A consistent pattern in the frequency of injuries for each period of centralized training was apparent. The number of injuries occurring per day of centralization peaked near the midpoint of each training period. A sub-peak in the number of injuries occurring per day was also seen near the beginning of each training period. The heights of the peaks decreased as the centralization progressed. When the injuries that occurred in each section of training were divided into chronic and acute injury, the pattern remained the same.

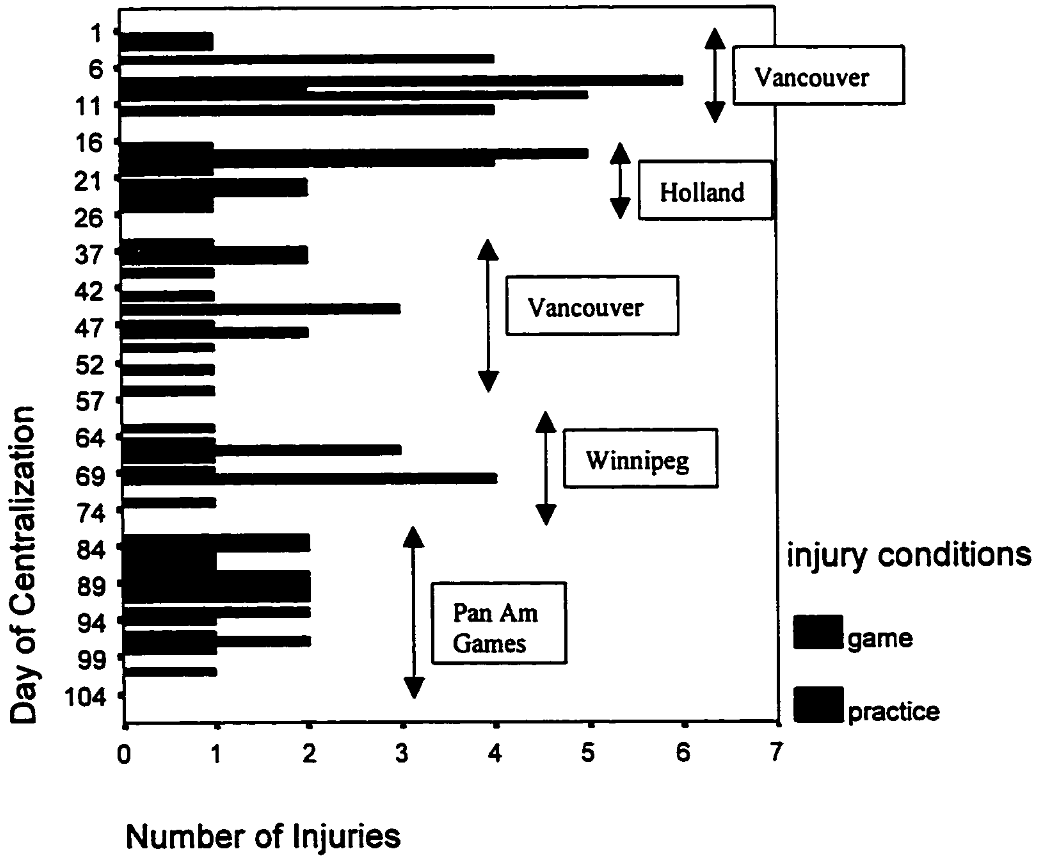

Figure 4.2. Number of Injuries per Day of Centralized Training

4.4 Patterns of Injury Occurrence

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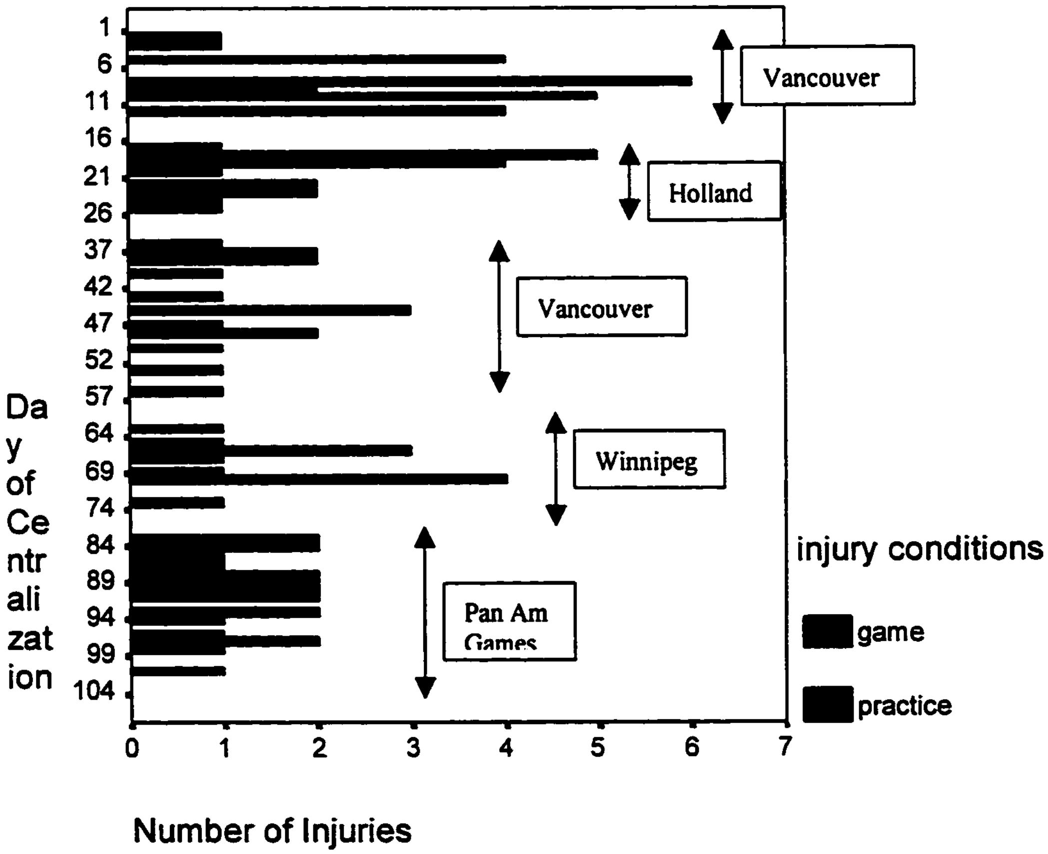

Figure 4.2. Number of Injuries per Day of Centralized Training

4.5 Nature of the Injuries

The types of injuries that occurred during the study period are displayed in Table 4.3. The injuries with highest frequency included fatigue/cramps/nonspecific joint trauma (17), muscle strain (15), tendinitis (12), postural mechanical dysfunction (12) and contusion (11).

Table 4.3.

Frequency of the Different Types of Injury

Type of Injury	Frequency	Percent
Local tissue fatigue/cramps/non-specific joint trauma	17	15.6
Muscle strain	15	13.8
Tendinitis	12	11.0
Postural mechanical dysfunction	12	11.0
Contusion	11	10.1
Sprain	8	7.3
Traumatic mechanical dysfunction	7	6.4
Neural tension/thoracic outlet	4	3.7
Joint degeneration	3	2.8
Plantar fasciatus	3	2.8
Iliotibial band syndrome	3	2.8
Fracture	2	1.8
Laceration	2	1.8
Burn	2	1.8
Peripheral joint dysfunction	2	1.8
Sprain with fracture	1	.9
Bursitis	1	.9
Patellar femoral syndrome	1	.9
Meniscal injury	1	.9
Concussion	1	.9
Heat injury	1	.9
Total	109	100.0

Postural mechanical dysfunction referred to chronic joint immobility and associated muscle imbalances in the spinal column and pelvis that were related to poor posture or poor body positioning during training. Sprains and traumatic mechanical dysfunction had the next highest frequencies (eight and seven, respectively). Traumatic mechanical dysfunction referred to acute joint immobility due to muscle spasm or joint subluxation in the spinal column and pelvis that was related to the application of some external force.

Table 4.4 demonstrates whether the injuries were new, recurred from previous training or were present when the athlete reported to the initial training period (ongoing). An injury was classified as recurrent if there was a history of previous injury to that area. While the majority of injuries were new, a high number of recurrent injuries also occurred. A chi square test determined that this pattern was significant, x^2 (4, N = 109) = 96.092, p<0.001.

Table 4.4.

Frequency of New, Recurring and Ongoing Injuries

Type of injury	Frequency	Percent
New	61	56.0
Recur from this centralization	15	13.8
Recur from field hockey prior to this centralization	20	18.3
Recur non-field hockey/other sport injury	2	1.8
Ongoing	11	10.1
Total	109	100.0

Table 4.5 illustrates the areas of the body where injuries were sustained. C/S, T/S and L/S referred to the cervical, thoracic and lumbar spines, respectively, and TMJ referred to the temperomandibular joint. The highest frequency of injury occurred in the knee (16), the hamstring (14), and the ankle (13).

Table 4.5.

Frequency of the Different Areas of the Body that were Injured

Area of injury	Frequency	Percent
Knee	16	14.7
Hamstring	14	12.8
Ankle	13	11.9
Quadricep	8	7.3
Pelvis	7	6.4
Calf	7	6.4
C/S	6	5.5
T/S	5	4.6
Wrist	5	4.6
Shoulder	4	3.7
Foot	4	3.7
Hip	3	2.8
Head	2	1.8
Mandible	2	1.8
Eye	2	1.8
Rib	2	1.8
L/S	2	1.8
TMJ	1	.9
Nose	1	.9
Chest/torso	1	.9
Elbow	1	.9
Hand	1	.9
Heel	1	.9
Toes	1	.9
Total	109	100.0

The data on the specific area of injury was condensed into the gross area of the body that was injured. The frequencies are displayed in Table 4.6. The highest percentage of injury occurred in the lower extremity (61.5%). The spine, which included injury to the cervical, thoracic, lumbar spine and pelvis, had the next highest percentage of injury (20.2%).

Table 4.6.

Frequency of Injuries that Occurred per Gross Area of the Body

Area of the body	Frequency	Percent
Lower extremity	67	61.5
Spine	22	20.2
Upper extremity	11	10.1
Head	8	7.3
Trunk	1	.9
Total	109	100.0

The classification of chronic or acute injury was explained previously (refer to Table 4.2). Table 4.7 divides injuries to gross area of the body into chronic and acute. Chronic injuries accounted for 55.0% (60) of the total injuries and acute injuries accounted for 38.5% (42) of the total injuries. The lower extremity and spine suffered a high frequency of chronic injury (40 and 14, respectively). The head suffered acute injury only (7). In 6.4% (7) cases, the cause of injury was unknown. Consequently, no classification of chronic or acute was made for these injuries.

Table 4.7.

Frequency of Chronic and Acute Injuries that Occurred for each Area of the Body

Area of the body	Chronic or acute injury		Total
	Chronic	Acute	
Upper extremity	6	4	10
Lower extremity	40	24	64
Head		7	7
Spine	14	6	20
Trunk		1	1
Unknown cause			7
Total	60	42	i09

All field hockey players hold their sticks on the same side of the body (that is, they all "shoot right"). In order to evaluate whether one side of the body was predisposed to injury over the other side, injuries were assigned to the left or right side of the body. If the injury occurred centrally to the spine or trunk, a classification of left and right was not entered. The left side of the body was injured in 41 cases; the right side was injured in 53 cases; no classification was made in 15 cases. Chi square was used to determine if a relationship existed between left or right side of the body and chronic or acute injury. No relationship existed between these variables, x^2 (1, N = 94) = 0.033, p = 0.86.

The incidence of injury in practices, games and conditioning was calculated previously. Because the incidence of injury in conditioning was extremely low (0.0041 injuries per hour), conditioning was excluded from further analyses. Injuries occurring in practices and games were also divided into chronic and acute (see Table 4.8). Chronic injuries occurred much more frequently in practices than acute injuries (38 vs 18). Conversely, acute injuries occurred much more frequently in games than did chronic injuries (22 vs 8). Chi Square test indicated that this relationship was significant, x^2 (1, N = 87) = 12.11, $p < 0.001$.

Table 4.8.

Frequency of Chronic and Acute Injuries that Occurred in Practices and Games

Activity	Chronic or Acute Injury		Total
	Chronic	Acute	
Practice	38	18	56
Game	8	22	30
Total	46	40	86

Incidence rates for each cell were also calculated. The incidence for chronic practice injuries was 0.022 injuries/hour; for acute practice injuries, 0.010 injuries/hour; for chronic game injuries, 0.0083 injuries/hour; and for acute game injuries, 0.022 injuries/hour.

In order to gain a clearer understanding of the extrinsic risk factors associated with field hockey injury in specific activities, practices and games were further differentiated by specific phases and chronic and acute injury (refer to Tables 4.9 and 4.10). No classification of chronic or acute injury was made in cases where the cause of injury was unknown. Consequently, Tables 4.9 and 4.10 do not include these cases. Chronic and acute injuries that occurred during each phase of practice are reflected in Table 4.9. Skill training involved all technical and tactical drills. Overwhelmingly, the majority of injuries occurred in skill training (44), and of these injuries, most were chronic (35). Acute injuries were evenly distributed between skill training and scrimmage (nine and eight, respectively).

Table 4.9.

Frequency of Chronic and Acute Injuries that Occurred in the Specific Phases of Practices

Phase of Practice	Chronic or Acute Injury		Total
	Chronic	Acute	
No specific time	2		2
Warm up		1	1
Skill training	35	9	44
Scrimmage	1	8	9
Total	38	18	56

Table 4.10 demonstrates the number of chronic and acute injuries that occurred during each phase of games. The majority of injuries occurred in the second half (15). Chronic injuries were reported in the second half (four) or at no specific time of the game (four) whereas the frequency of acute injuries increased as the game progressed through the phases.

Table 4.10.

Frequency of Chronic and Acute Injuries that Occurred in the Specific Phases of Games

Phase of Game	Chronic or Acute Injury		Total
	Chronic	Acute	
No specific time	4		4
Warm up		3	3
1st half		8	8
2nd half	4	11	15
Total	8	22	30

4.6 Cause of Injury

The causes of injury are displayed in Table 4.11. The most common cause of injury was overuse (49.5%), followed by contact (24.8%) and mechanical stress (14.7%). Unknown referred to injuries where the athlete could not recall any precipitating factor that lead to the injury. Accident referred to injuries that the therapist assessed and treated but that had nothing to do with training (e.g. post-tournament celebration injuries or injuries in the home).

Table 4.11.

Frequencies of the Different Causes of Injury

Cause of the injury	Frequency	Percent
Unknown	7	6.4
Contact	27	24.8
Mechanical stress	16	14.7
Overuse	54	49.5
Combination mechanical stress and contact	3	2.8
Accident	2	1.8
Total	109	100.0

When the cause of injury was differentiated by the type of injury, the following relationships were noted. Contact was associated mostly with the acute injuries of contusions (11) and traumatic mechanical dysfunction (6). Mechanical stress was associated mostly with acute sprains (5), and to a lesser degree with chronic muscle strains (4) and joint degeneration (3). Overuse was associated with the chronic injuries of fatigue/cramps/non-specific joint trauma (13), muscle strain (11), postural mechanical dysfunction (11) and tendinitis (8).

Contact was divided into specific types. This distribution is presented in Table 4.12. Contact by the ball (11) was the most frequent cause of contact injury followed by the ground (8) and another player (6).

Table 4.12.

Frequency of the Causes of Contact Injury

Type of contact	Frequency	Percent
Stick	3	10.0
Ball	11	36.7
Another player	6	20.0
Ground	8	26.7
Combination ground and player	2	6.7
Total	30	100.0

When cause of injury was divided into the phases of practices and games, the distributions presented in Tables 4.13 and 4.14 arose. No specific time in both tables referred to injuries that the athlete reported as gradually worsening throughout the course of the activity without being specifically related to any one phase or that the athlete only became aware of at the end of the activity.

Table 4.13 shows that during practices, most injuries occurred in skill training (44) and were due to overuse. Contact injuries occurred equally in skill training (six) and scrimmages (five).

Table 4.13.

Causes of Injury for the Phases of Practice

Cause of the Injury	Phase of Practice				Total
	No specific time	Warm up	Skill training	scrimmage	
Contact		1	6	5	12
Mechanical stress			3	1	4
Overuse	2		35	1	38
Combination mechanical stress and contact				2	
Total	2	1	44	9	56

Table 4.14 shows that during games, overuse injuries were reported in the second half (four) or at no specific time (five). Injuries due to mechanical stress occurred with greater frequency in the first half (four) than any other time of the game.

Contact injuries occurred with increasing frequency as the game progressed through the phases.

Table 4.14.

Causes of Injury for the Phases of Games

Cause of Injury	Phase of game				Total
	No specific time	Warm up	1st half	2nd half	
Contact		1	4	9	14
Mechanical stress		1	4	2	7
Overuse	4			4	8
Combination mechanical stress and contact		1			1
Total	4	3	8	15	30

As contact was the most frequent cause of injury in games, it was evaluated in further depth (see Table 4.15). Contact by the stick, another player and the ground are evenly distributed throughout the game (three, three and four, respectively). Contact by the stick and the ball increased as the game progressed through the phases.

Table 4.15.

Cause of Contact Injury for the Phases of Games

Type of contact	Phase of game			Total
	Warm up	1st half	2nd half	
Stick		1	2	3
Ball	1		4	5
Another player		2	1	3
Ground	1	1	2	4
Total	2	4	9	15

4.7 Severity of Injury

The severity of injuries is depicted in Table 4.16. The majority of injuries that occurred during the centralized training period were of moderate severity (58.7%).

Table 4.16.

Frequency of the Severity of Injuries

Level of severity	Frequency of injury	Percent
Mild	12	11.0
Mild/moderate	19	17.4
Moderate	64	58.7
Moderate/severe	14	12.8
Total	109	100.0

Severity was crosstabulated with the types of training, gross area of the body, chronic injuries, left or right side of the body, the phases of the practices and games, the history of a previous injury, the equipment worn at the time of injury and whether the injured athlete was braced or taped at the time of the injury. The pattern shown in Table 4.16 remained constant with respect to all these variables with the following exceptions. The upper extremity and spine suffered a higher frequency of moderate injuries (90.9% and 72.7%, respectively). Head injuries were either predominantly mild (37.5%) or moderate/severe (37.5%) in severity. Mild and moderate/severe acute injuries occurred with higher frequency (17.5% and 22.5%, respectively). In games, a higher frequency of mild (23%) and mild/moderate (23%) injuries occurred in the second half. Mild and moderate/severe contact injuries occurred with higher frequency (22.2% and 22.2%, respectively).

The relationship between severity of injury and the history of a previous injury was evaluated with the chi square test. Having a history of previous injury did not predispose the athlete to a higher level of severity of recurrent injury, x^2 (3, $\underline{N}$ = 109) = 3.73, p = 0.29.

4.8 Playing Position

The frequency of injuries that occurred in games for each playing position in field hockey is presented in Table 4.17. Practices rarely used the entire field or placed players in their usual game positions. Scrimmages either occurred on only half the field or did not have 11 players per team (the usual number of players in field hockey). Because field position would not have been accurately represented in these situations, field position was recorded for games only. Table 4.17 illustrates that there was an even distribution of injuries throughout the field positions (forward, 9; midfield, 9; defense, 10) and that goalies suffered fewer injuries than field players (2).

Table 4.17.

Frequency of Injuries that Occurred Amongst the Various Playing Positions

Playing position	Frequency of injury	Percent
Forward	9	30.0
Midfield	9	30.0
Defense	10	33.3
Goalie	2	6.7
Total	30	100.0

The field hockey pitch was divided into eight zones and the frequency of injury per zone during games was recorded. These frequencies are presented in Figure 4.3. There was a higher frequency of injury in the midfield zones (12). The frequency of injury of the left and right sides of the field, excluding the defensive and offensive circle, was the same (9). The type of injury that occurred in each area was also investigated and no pattern was present.

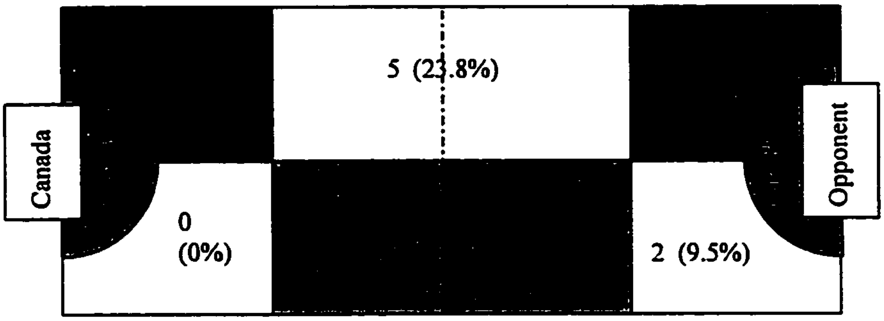

Figure 4.3. Total number of injuries that occurred in each zone of play for all the games played during centralized training.

4.9 Weather Conditions

The distribution of injuries that occurred over the different weather conditions during the period of centralized training is displayed in Table 4.18. Weather conditions were not entered for ongoing injuries or activities such as weight training where weather was not a factor (17 cases). The frequency of injury was distributed evenly throughout the different weather conditions.

Table 4.18.

Frequency of Injuries that Occurred in Different Weather Conditions

Weather conditions	Frequency of Injury	Percent
Overcast	18	19.6
Rain	11	12.0
Mixed sun and cloud	18	19.6
Overcast with wind	10	10.9
Sunny	23	25.0
Sunny with wind	12	13.0
Total	92	100.0

The pattern of injury shown in Table 4.18 did not change when injuries were divided into chronic and acute. The relationship between turf temperature and frequency of injury is shown in Figure 4.4. The incidence of injury in conditioning activities was very low. Consequently, the effect of temperature was considered on injuries that occurred in practices and games only. Because all practices and games occurred on turf, only the effect of turf temperature on injury was analyzed. Ambient temperature was generally a few degrees lower than the turf temperature. Figure 4.4 reveals that there is no relationship between turf temperature and the frequency of injury.

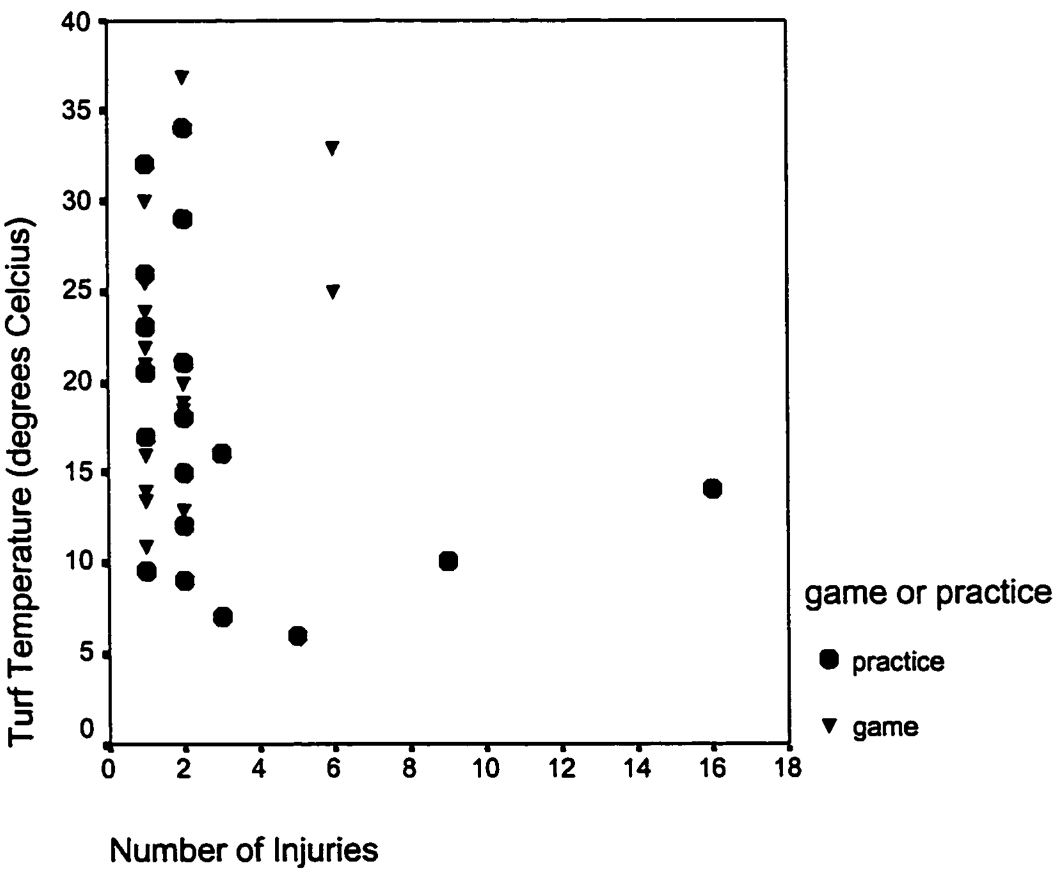

Figure 4.4.

The number of injuries that occurred per practice or game session versus turf temperature.

4.10 Equipment

Equipment in field hockey is used to protect the player from injury due to contact. The types of equipment worn by field players were shin guards, which covered the shin only, and mouth guards. Goalies wore high density foam padding that covered the feet, the lower two thirds of the lower extremity, and the anterior torso, arms and hands. Helmets and mouth guards were also worn by the goalies. The type of equipment worn was entered when the cause of injury was contact or when the injured area was protected by equipment at the time of injury (30 cases). No entry was made for chronic injuries or injuries that were caused by overuse or mechanical stress. Table 4.19 shows the area of the body that was injured with respect to the type of contact that caused the injury. Knees (six) and ankles (four) had the highest frequency of contact injuries. The majority of areas that were injured as a result of contact were areas that were not covered by protective equipment.

Table 4.19.

Frequency of the Type of Contact for Each Area of Injury

Area of the Body	Type of contact causing injury: Stick	ball	Another player	ground	Combination ground and player	Total
Head			1			1
TMJ		1				1
Mandible		2				2
Nose		1				1
Eye		1	1			2
C/S			1		1	2
T/S				2		2
Chest/torso		1				1
Rib			1			1
Shoulder				2		2
Wrist		1		1		2
L/S				1		1
Knee	2	2		2		6
Ankle	1		2		1	4
Heel		1				1
Toes		1				1
Total	3	11	6	8	2	30

Table 4.20 shows the different types of injuries that occurred from contact with respect to the protective equipment worn. Contact with players, the ground or a combination of these two (a total of 8 injuries) led predominantly to sprains, non-specific joint trauma and traumatic mechanical dysfunction. Contact by the ball (11) or stick (3) lead predominantly to fracture, contusion and laceration. Goalies suffered more traumatic mechanical dysfunction (3) than field players. Field players suffered more contusions (10) and lacerations (2) than goalies. The ratio of ball or stick contact injury to player or ground contact injury was 0.5:1 for goalies and 3:1 for field players.

Table 4.20.

Frequency of the Types of Contact Injuries for the Different Types of Equipment Worn

Type of injury	Type of contact	Equipment worn		Total
		Full goalie equipment	Mouthguard and shinguards	
Sprain	Ball		1	1
	Combination ground and player		1	1
Local tissue fatigue/ cramps/non-specific joint trauma	Another player	1		1
	Ground		1	1
Fracture	Ball	1	1	2
Contusion	Stick		2	2
	Ball	1	7	8
	Another player		1	1
Laceration	Stick		1	1
	Ground		1	1
Traumatic mechanical dysfunction	Ground	2		2
	Combination ground and player	1		1

4.11 Bracing and Taping

Table 4.21 shows whether or not bracing or taping was used at the time of injury for each type of injury that was recorded. The present study did not investigate intrinsic factors associated with injury. As orthotics are most often used to address biomechanical factors (intrinsic) that affect injury, their use was not recorded in the data. No entry was made in four cases where the injury occurred outside of field hockey related activities (e.g., burn). Bracing and taping is used to prevent acute joint injuries. While table 4.21 shows that the majority of injuries were not braced or taped at the time of injury, the types of injuries that occurred at the highest frequencies (tendinitis, 11; muscle strain, 12; local tissue fatigue/cramps/nonspecific joint trauma, 13; contusion, 11; postural mechanical dysfunction, 11) were injuries that would have been difficult to brace or tape.

Table 4.21.

Crosstabulation of Whether or Not the Player was Braced or Taped at the Time of Injury

Type of injury	Injured structure braced/taped at the time of injury		Total
	Yes	No	
Tendinitis		11	11
Sprain	1	7	8
Sprain with fracture		1	1
Muscle strain	3	12	15
Local tissue fatigue/cramps/non-specific joint trauma	4	13	17
Joint degeneration		3	3
Fracture		2	2
Bursitis		1	1
Plantar fasciatus		3	3
Patellar femoral syndrome		1	1
Iliotibial band syndrome		3	3
Meniscal injury		1	1
Contusion		11	11
Laceration	1	1	2
Concussion		1	1
Heat injury		1	1
Postural mechanical dysfunction		11	11
Traumatic mechanical dysfunction		7	7
Peripheral joint dysfunction		2	2
Neural tension/thoracic outlet		4	4
Total	9	96	105

4.12 References

Meeuwisse, W. and Love, E. (1998). Development, implementation and validation of the Canadian intercollegiate sport injury registry. Clinical Journal of Sport Medicine, 8(3), 164 – 177.

CHAPTER 5

Discussion

5.1 Introduction

A prospective observational cohort study was undertaken to ascertain the patterns and nature of injuries and the extrinsic factors associated with these injuries that occurred during the Canadian women's national field hockey team's preparation for the 1999 Pan American Games. Preparation for the Pan American Games was completed through centralized training. This training took place in a number of locations – April 26 to May 7 in Vancouver, May 10 to May 21 in Holland, May 31 to June 20 in Vancouver, June 26 to July 9 in Winnipeg and July 17 to August 8 (Pan American Games) in Winnipeg. The major findings of this study include the following. The incidence of injury was 0.034 injuries per hour. Each section of centralization had a peak of injury frequency near the midpoint and a sub-peak of injury frequency near the beginning. Chronic injuries caused by overuse, including fatigue, cramps and non-specific joint trauma, muscle strains, tendinitis and postural mechanical dysfunction, occurred most frequently during skill training in practices. Acute injuries caused by contact and mechanical stress, such as contusions, sprains and traumatic mechanical dysfunction, occurred more frequently in games than in practices, and more frequently in the second half. The majority of injuries were of moderate severity. The lower extremity comprised 61.5 % of the total injuries and the spine comprised 20.2 % of the total injuries. Left or right side of the body, history of previous injury, playing position, weather conditions and temperature, protective equipment and bracing or taping had no effect on frequency or severity of injuries.

Few studies on field hockey exist. Consequently, the discussion of the results of the present study must also make comparisons to sports with a similar nature to field hockey. Hurling is a running sport played on a field of similar dimensions to a field hockey pitch. Both field hockey and hurling involve a ball being propelled by a stick, although in hurling the stick is used more often overhead. Soccer is a running game, played on a field of similar dimensions and with the same number of players as field hockey. Soccer and field hockey both involve relatively continuous open field play, lateral movement, twisting and turning of the torso and the potential for body contact (Bauman, Harris, Jones & Knapik, 1992; Singh & Williams, 1997). However, soccer does not have the same degree of trunk flexion that is seen in field hockey. Rowing involves repetitive forward flexion and twisting of the lumbar spine like field hockey but it is not a running sport with the potential for contact injuries.

5.2 Incidence

The present study found an overall incidence rate of injury to be 0.034 injuries per hour of exposure to training and practice. This rate can also be expressed as 34.3 injuries per 1000 hours of exposure. Similarly, the incidence of injury in practices (0.034 injuries/hour) and games (0.034 injuries/hour) can be expressed as 33.6 injuries per 1000 hours and 34.1 injuries per 1000 hours, respectively. The risk of injury in practices and games in the present study was equal. There was a very small risk of injury in conditioning activities (.0041 injuries/hour).

When chronic and acute injuries were divided into practice and games, the following incidence rates were found: chronic practice injuries, 0.022 injuries/hour; chronic game injuries, 0.0083 injuries/hour; acute practice injuries, 0.010 injuries per hour; and acute game injuries, 0.022 injuries/hour. The risk of chronic practice injury and acute game injury was the same, as was the risk of acute practice injury and chronic game injury.

A prospective injury study on two club and two county squad hurling teams (74 athletes) used the same definition of injury as the present study (Watson, 1996). A similar rate of injury for games (34.3 injuries per 1000 hours) as the present study was found but a much smaller rate of injury for practices (4.4 injuries per 1000 hours) occurred (Watson). Engstrom, Johansson and Tornkvist (1991) performed a one year prospective injury study on two elite women's soccer teams (one premier division, one second division). The season was broken into preseason training from November to January, training games from January to April and regular league play from April to October. Engstrom et al. defined injury as occurring during training or a game that resulted in an at least one session absence from at least one session. The researchers found an incidence of 24 injuries per 1000 hours for games and 7 injuries per 1000 hours for practices. When the results of the present study are adapted to match the soccer definition of injury, the incidence of injury for field hockey games was similar to that of soccer (23.8 injuries per 1000 hours), but the incidence of field hockey injuries in practice was much higher (20.6 injuries per 1000 hours). While the incidence of injury of the Canadian women's national team in games is similar to other sports such as hurling and soccer, the incidence of injury in practices is much higher.

In both the hurling and soccer studies, acute injuries occurred much more frequently than chronic injuries (Engstrom et al., 1991; Watson, 1996). Engstrom et al. found that 72 % of the total injuries were acute and occurred mainly in games while only

28 % of the total injuries were chronic and occurred mainly in preseason training and at the beginning and ends of the competitive season. In the present study, chronic injuries occurred more frequently than acute injuries and occurred most often in practice. This difference in frequency of chronic and acute injuries could account for the difference in injury incidence seen between field hockey, hurling and soccer in practices. Training intensity might have also played a role. At high levels of play, overuse injuries are more common (Bol, Inklaar, Mosterd & Schmikli, 1996). Eckstrand and Gillquist (1983) studied 180 senior male soccer players in the Swedish Division I and Division IV leagues. Each team participated in an average of 95 practices and 36 games. Eckstrand and Gillquist found 84 % of all overuse injuries occurred in practice. Training volume might also account for the difference in incidence in chronic injury. Fricker, Hickey and McDonald (1997) performed a 10-year retrospective study on national level rowers training at the Australian institute of sport. On average, each athlete completed 10 to 16 two- hour rowing sessions and two to three weight training sessions per week. Fricker et al. found the ratio of acute to chronic injuries to be 1:2.48. This rate for the present study was 1:1.45. The percentage of chronic injuries between these two studies was similar but field hockey had a higher incidence of acute injuries. The training frequency, reported in this rowing study, more closely resembled the training frequency of the Canadian national field hockey team than the field hockey, hurling and soccer studies cited above. Acute injuries with the national field hockey team occurred more frequently in games. This finding is similar to the findings of Eckstrand & Gillquist (1983), where two thirds of all acute injuries occurred in games.

When incidence was considered in relation to the distribution of injuries among athletes, two athletes accounted for 24 of 109 (22 %) of the injuries and six athletes accounted for 58 of 109 (53.2 %) of the injuries. Although these figures demonstrate that a relatively small number of athletes accounted for a large number of injuries, these figures do not reflect the types of injuries or the severity of these injuries. The types of injuries were a mixture of chronic and acute injuries with a slightly higher percentage of acute injury than the percentage seen in Table 4.7. In relation to the pattern in severity of injury shown in Figure 4.16, there was only a slightly higher percentage of moderate/severe injuries among the six athletes.

5.3 Patterns of Injury Occurrence

The present study found a peak in the frequency of injuries near the midpoint of each section of centralization and a sub-peak in the frequency of injuries near the beginning of each section of centralization. The height of the midpoint peak decreased as the centralization progressed. This decrease reflected a decrease in the number of participants rather than a change in incidence. Eckstrand and Gillquist (1983), Engstrom et al. (1991) and Fricker et al. (1997) included a similar analysis in their respective studies. However, none of the researchers included a discussion of their findings. Comparison of the findings in soccer and rowing with the present study was impossible without a much greater knowledge of the training volume and intensity and of the competitive schedule of the soccer and rowing groups.

The peaks in injury frequency in the present study remained when the total injuries were divided into chronic, acute and practice injuries. This consistency suggested that the athletes involved in centralized training reached points in each training section where they were susceptible to both chronic and acute injury. Fatigue and overuse may have played a role. In every training section, the team participated in more practices at the beginning of the section and more games from the midpoint to the end of each section. The nature and demands of this schedule may have contributed to the pattern observed. The lack of consistency of the pattern for games also suggested that the schedule may have been a factor. As games tended to be played from the midpoint to the end of each training section, the appearance of a peak at the midpoint of each section would have been unlikely when games alone were considered. While the pattern shown suggested the demands of the schedule may have been a factor, without further analysis of potential intrinsic risk factors to injury and the specific nature of practice drills (i.e., intense running drills versus strategic drills), any explanation of the pattern observed would be purely speculative.

5.4 Nature of the Injuries

5.4.1 The types of injuries observed.

The types of injury most frequently reported in the present study included local tissue fatigue/cramps/non-specific joint trauma (15.6 %), muscle strain (13.8 %), tendinitis (11 %), postural mechanical dysfunction (11 %) and contusions (10.1 %). Previous studies on field hockey similarly showed that contusions, lacerations, abrasions, muscle-tendon strains and sprains occurred with high frequency (Cunningham & Cunningham, 1996; Jamison & Lee, 1989; Rose, 1981; Whitney, 1983). Cunningham and Cunningham tracked injuries that occurred at the 1994 Australian University Games. The researchers found that in field hockey the most frequently reported injuries were contusions (27.6 %), strains (19.3 %), sprains (14.9 %), abrasions (13.8 %) and lacerations (7.7 %). Jamison and Lee compared the injuries that occurred at the 1994 and 1995 Australian National Women's Hockey Championships played on grass and artificial turf, respectively. On grass, contusions (64 %), abrasions (14 %), strains (5 %), sprains (2 %) and lacerations (2 %) occurred most frequently. On artificial turf, contusions (49 %), abrasions (13 %), lacerations (12 %), strains (12 %) and sprains (2 %) occurred most frequently. Rose's study on women's field hockey at California State University found that contusions (32.1 %), sprains (29.6 %), strains (7.4 %), bursitis/tendinitis (4.9 %) and lacerations (3.7 %) occurred most frequently. At the 1979 World Cup of Field Hockey, Whitney found the British women's national field hockey team suffered strains (25 %), contusions (20 %), sprains (15 %) and lacerations (10 %) most frequently. Most of these studies considered games only. Consequently, contusions and lacerations were found to occur with higher frequency than in the present study.

Studies on hurling and soccer also showed similar results to the present study (Bol et al., 1996; Inklaar, 1994; Watson, 1996). In hurling, Watson found strains (24 %), contusions (16 %) and sprains (15.5 %) to occur most frequently. Eckstrand and Gillquist (1983) found that the injuries that occurred the most frequently were sprains (29 %), bursitis/tendinitis (23 %), contusions (20 %) and strains (18 %). Engstrom et al. (1991) found sprains (33 %), bursitis/tendinitis (24 %), contusions (15 %) and strains (10 %).

5.4.2 The area where injuries occurred.

The present study on the national field hockey team showed that the most frequently injured areas were the lower extremities (61.5 %) and the spine (20.2%). Specifically, the highest frequency of injury occurred at the knee (14.7 %), hamstring

(12.8 %) and ankle (11.9 %). Jamison and Lee (1989) also found a high frequency of lower extremity injuries (grass, 77 %; turf, 58 %) in field hockey, especially to the knee (grass, 24.5 %; turf, 17.9 %), shin (grass, 5.5 %; turf, 12.6 %) and foot (grass, 7.3 %; turf, 3.2 %). Rose (1981) found 65.4 % of all injuries occurred to the lower extremity, especially the ankle (27.2 %), foot (12.3 %) and knee (11.1%). Watson (1996) reported the highest frequency of injury in hurling to the fingers (13 %), hamstrings (12 %), back (11 %), knees (9.5 %) and head (9.5 %). The higher frequency of finger and head injuries were found because, unlike field hockey, the ball is often played overhead (Watson). Soccer studies also found a high frequency of injury to the lower extremity, especially the knee, thigh, groin, foot and ankle (Bol et al., 1996). Eckstrand & Gillquist (1983) found that injuries occurred most frequently to the knee (20 %), ankle (17 %), thigh (14 %) and groin (13 %). Engstrom et al. (1991) found that the ankle (26 %), knee (23 %), and thigh (15 %) were injured most frequently. Hendy, Lindenfield, Mangine, Noyes and Schmitt (1994) studied injuries that occurred to male and female indoor soccer players (ages ranging from 7 to 50 years) during a seven-week competitive season. The researchers found that the knee (23 %) and ankle (23 %) were injured most frequently. As with the present study, Engstrom et al. (1991) found that soccer injuries were equally distributed between left (42 %) and right (49 %) sides of the body.

The spine was not cited in soccer studies as a frequent area of injury. A major difference between field hockey and soccer is that field hockey requires the athlete to twist from side to side while in a forward flexed position. Rowing, like field hockey, also requires the athlete to twist and forward flex. In a study on elite rowers, Fricker et al.

(1997) found that 25 % of injuries to male and female rowers occurred in the lumbar spine. This percentage more closely resembles the findings of the present study (20.2 % of all injuries occurred to the spine) than the soccer studies cited above.

5.4.3 The causes of injury.

The most frequent causes of injury for the national women's field hockey team were overuse (49.5 %), followed by contact (24.8 %) and mechanical stress (14.7 %). Whitney (1983) found the most frequent cause of injury to the members of the English field hockey team at the 1979 Women's World Cup to be contact (47.1 %) followed by mechanical stress (36.8 %) and overuse (15.8 %). Jamison and Lee (1989) also found contact injuries to be the most frequent cause of injury (grass, 88 %; turf, 82 %). Cunningham and Cunningham (1996) found contact accounted for 59.7 % of all field hockey injuries; running, 16 %; mechanical stress, 13.3 %; and overuse, 6.1 %. All of the studies listed above evaluated game play only. When the causes of injury of the Canadian women's national team in games only were calculated, contact accounted for 46.7 % of all game injuries; overuse, 26.7 % and mechanical stress, 23.3 %. When the causes of injuries for the Canadian women's team in games only were compared to the findings listed above, the causes of injury were very similar between all the studies.

In soccer, Ekstrand & Gillquist (1983) found 59 % of traumatic injuries was due to player to player contact and Engstrom et al. (1991) found 80 % of all traumatic injuries was due to player to player contact. The present study found the ball (36.7 %) was the most frequent cause of traumatic (contact) injury rather than player to player contact

(20 %). The difference between these studies revealed the differences in the nature of the games. Soccer involved players jumping to head the ball and tackling with feet and legs while field hockey involved the use of a stick and ball.

Because the majority of injuries of the Canadian team occurred in practice and were chronic in nature, the overall highest cause of injury was overuse. In the rowing study by Fricker et al. (1997) where, as in the present study, the amount of time spent in practice was greater than the amount of time spent in competition, overuse was also the most frequent cause of injury (71.3 %).

5.4.4 The severity of the injuries.

The present study defined severity both by treatment required and by time missed. To compare the present findings on severity to other studies, the definition of severity used for reporting purposes had to be adapted to match the definitions in other literature. In the Ekstrand and Gillquist (1983) study on male soccer players and the Engstrom et al. (1991) study on elite female soccer players, the authors defined severity only by absence from practice or games. Minor severity was an absence less than one week; moderate severity was an absence from one week to one month; major severity was an absence greater than one month. The following matches between the definition of the present study and the definition described above were made: mild, mild/moderate and moderate injuries became minor injuries; moderate/severe injuries became moderate injuries; severe injuries became major injuries. Eckstrand and Gillquist (1983) found that 62 % of the total injuries to be minor, 27 % to be moderate and 11 % to be major. Engstrom et al. (1991) found 49 % of the total injuries to be minor, 36 % to be moderate and 15 % to be major. The present study found 87.1 % of the total injuries to be minor, 12.8 % to be moderate and no major injuries.

Both soccer studies found a lower percentage of minor injuries and a higher percentage of both moderate and major injuries. The differences in these findings can be explained by the difference in the nature of the injuries. Firstly, a much higher percentage of chronic injuries existed in the present study than in any of the soccer studies previously described. It is more likely that one would be able to treat an athlete for a chronic condition, such as chronic low back pain, and maintain her level of participation than it would be to treat and maintain participation levels for an athlete with a traumatic acute injury, such as a knee ligament sprain. Secondly, there was a much higher percentage of body to body contact injuries (Eckstrand & Gillquist [1983], 59 %; Engstrom et al. [1991], 80 %) resulting in knee and ankle sprains and concussions in the soccer studies than in the study on the national field hockey team (20 %). When absence from practice or games is the only criteria for defining severity, these types of injuries tend to be defined as moderate to severe.

According to the definition of severity for the present study, 11 % of the total injuries were mild, 17.4 % were mild/moderate, 58.7 % were moderate and 12.8 % were moderate/severe. History of previous injury did not affect the severity of injury. However, when the total injuries were divided into gross area of the body, and acute, contact and game injuries, some exceptions to the pattern of severity outlined above existed. The upper extremity and spine suffered a higher percentage of moderate injury (90.9 % and 72.7 %, respectively). Because severity was based on treatment and absence from field hockey related activity, the difference in frequency of moderate upper extremity and spine injury illustrated that these types of injuries required more treatment and lead to more time loss than injuries to other areas of the body. The head suffered more mild (37.5 %) and moderate/severe (37.5 %) injury. Head injury was caused by contact by the ball, stick or another player, which lead to contusions and concussion. Contusions required little or no treatment and were classified as mild while the concussion lead to a one-week absence from activity and was classified as moderate/severe. These classifications lead to higher frequencies in the mild and moderate/severe categories. Mild and moderate/severe acute injuries (17.5 % and 22.5 %, respectively) and mild and moderate/severe contact injuries (22.2 % and 22.2 %, respectively) occurred with higher frequency than the overall rate described above. In games, a higher percentage of mild (23 %) and mild/moderate (23 %) injuries occurred in the second half. These three differences in frequency of severity were related. Acute contact injuries predominantly included contusion, sprain, traumatic mechanical dysfunction, fracture and laceration. Contusions required little or no treatment and absence from activity while sprains, traumatic mechanical dysfunction, fracture and laceration required a higher level of treatment and absence from activity. Consequently, these contact injuries were classified either as mild or moderate/severe, which lead to higher percentages in these categories of severity. Contact injuries were the most frequent cause of injury in games (46.7 %). Ball and stick contact injuries occurred more frequently in games than practices and more frequently in the second half. Ball and stick contact lead predominantly to contusions. These types of contact injuries required little or no treatment and, consequently, were classified as mild or mild/moderate leading to a higher percentage in these categories.

5.4.5 The extrinsic risk factors associated with injury.

Injuries to members of the national field hockey team were not affected by playing position, specific area of the pitch where the injury occurred, weather conditions or turf temperature. The present study found that forwards suffered 9 injuries, midfielders suffered 9 injuries, defenders suffered 10 injuries and the goalies suffered 2 injuries. These figures were based on the number of players on the field at any given time (11) rather than the total number of players on the team (16). The Canadian system of play often employs three forwards, three midfielders, four defenders and one goalie. If the number of injuries for each position were divided by the number of players in that position, 3 injuries occurred per forward, 3 injuries occurred per midfielder, 2.5 injuries occurred per defender and 2 injures occurred per goalie. There was an even distribution of injuries throughout the positions. An even frequency of injuries per playing position has also been found in studies on hurling and soccer (Ekstrand & Gillquist, 1983; Engstrom et al., 1991; Fuller & Hawkins, 1998; Hendy et al., 1994; Watson, 1996).

The present study divided the pitch into eight zones: an offensive circle, 14.6 m in radius from the offensive endline; a defensive circle, 14.6 m in radius from the defensive endline; the defensive end, from the defensive endline to the defensive 22.9 m line excluding the defensive circle; the midfield, from the defensive 22.9 m line to the offensive 22.9 m line; and the offensive end, from the offensive 22.9 m line to the offensive endline excluding the offensive circle. The defensive end, midfield and offensive end were divided into left and right. When game injuries were divided into the zones on the field where the injury occurred, 56.5 % of the injuries occurred in the midfield, 17.4 % in the defensive end, 13 % in the offensive end, 8.7 % in the defensive circle and 4.3 % in the offensive circle. The Canadian style of play involved more play in the midfield zone than in either the defensive or offensive ends and circles. Consequently, although the percentage of injury that occurred in the midfield is higher than any other area of the pitch, the higher frequency did not necessarily indicate an increased risk of injury in the midfield. Side of the field did not influence injury occurrence. When the field was divided into left and right, an equal percentage of injuries occurred per side of the field (42.9% each). Ekstrand and Gillquist (1983) similarly found that injuries were not affected by specific area of the field where the injury occurred.

The present study showed that weather conditions of turf temperature did not affect the frequency of injury to members of the national field hockey team. Similar findings existed with studies on hurling and soccer (Engstrom et al., 1991; Watson, 1996).

The majority of injuries (91.4 %) that occurred to the members of the Canadian women's national team occurred while the athletes were not braced or taped. Overuse was the most frequent (49.5 %) cause of injury leading to local tissue fatigue/cramps/non-specific joint trauma (15.6 %), muscle strain (13.8 %), tendinitis (12 %) and postural mechanical dysfunction (11 %). These types of chronic injuries occur as a result of repetitive microtrauma (Fieseler, Howard, Nirschl & O'Connor, 1997). Bracing or taping prevents abnormal excessive range of motion of a given joint that might lead to an acute injury (Arnheim, 1997). Bracing or taping would only prevent chronic injury if the cause of that injury were abnormal excessive range of motion leading to microtrauma and if the area susceptible to this injury could be effectively braced or taped. While bracing or taping was not used in the majority of injuries, the most frequently occurring injuries were both chronic in nature and difficult to brace or tape, suggesting that bracing or taping did not affect the occurrence of injury.

5.5 Chronic Injury

One goal of the present study was to indicate where preventive measures might be required to reduce injuries. The results of the present study found that 58.8 % of the total injuries were chronic (refer to table 4.7). The most frequent types of injury were local tissue fatigue/cramps/non-specific joint trauma, muscle strain, tendinitis and postural mechanical dysfunction. The high frequency and chronic nature of these injuries present an area of concern. Overuse injuries occur from repetitive microtrauma that leads to inflammation and local tissue damage (Fieseler et al., 1997). The highest number of chronic injuries occurred in practice, specifically in skill training. Skill training was the most repetitive part of practice where specific techniques were performed over and over. The skill training phase of practice also incorporated physical conditioning. Sport specific skills were practiced at game intensity. More body to body contact between players and greater intensity of effort during drills occurred than in previous years. Chronic injuries in games occurred towards the end of the game. Both of these situations suggested that the onset of injury is affected by repetition and fatigue.

Fatigue can play a significant role in the onset of chronic injury. In field hockey, fatigue comes both from running and from repetitive bending and twisting. Glace, Gleim and McHugh (1998) found that prolonged running lead to significant decreases in hip strength, particularly in abduction, adduction and flexion. In field hockey, the player must run not only for 70 minutes, but also in a forward bent position in order to keep the stick close to the ground. The skill requirements and postural stresses of the playing position are superimposed on the work-rate demanded by the running nature of the game (Reilly & Seaton, 1990). Running in this semi-crouched position is an ergonomically unsound posture for fast locomotion and imposes a physiological strain over and above normal running (Fox, 1981; Reilly & Seaton).

Studies on repetitive lifting and bending tasks have shown changes in coordination of movement and balance with fatigue. At the end of a repetitive lifting task from midshank to waist, Parnianpour, Reinsel, Simon and Sparto (1997) found that knee and hip range of motion significantly decreased and that peak lumbar flexion significantly increased. Parnianpour et al. felt that the increase in lumbar flexion could increase the risk for low back injury, especially due to gradual disc prolapse and increased facet contact forces. Normal function involves optimal timing and coordination of trunk and back muscle contraction. Knee extension leading hip extension leading lumbar spine extension was the typical coordination of a lift (Parnianpour et al.). With repetitive lifting, however, hip and knee extension occurred earlier in the cycle and the anteroposterior excursion of the center of balance increased (Parnianpour et al.). Both these changes reflect a change in motor coordination. Balance and proprioception have also been shown to be hampered in individuals with low back pain (Herring & Kaul, 1998; Jull, Lam & Treleaven, 1999). Persons with unilateral low back pain have increased center of gravity sway during a balance tests with eyes open and closed (Alexander & Kinney LaPier, 1998; Herring & Kaul; Jull et al.). A study on repositioning to a neutral position of the lumbar spine from full flexion showed that individuals with low back pain had difficulty finding lumbar neutral (Jull et al.). Fenety and Kumar (1992) studied field hockey players with low back pain. They found that field hockey players experiencing low back pain had a decrease in lumbar spine extension and total range of motion and had a weaker peak eccentric strength of lumbar spine extension than their non-painful counterparts. They felt that all field hockey players have a risk of decreased lumbar extension, strength and range of motion regardless of low back pain (Fenety & Kumar). These impairments of coordination, balance and proprioception due to fatigue and low back pain are involved in injury (Ekstrand & Gillquist, 1983b; Herring & Kaul; Jull et al.; Parnianpour et al.). The physiological cost of running combined with repetitive squatting motions to send and receive passes and to tackle cause local muscular fatigue. This fatigue can predispose the athlete to injury and will affect coordination of movement, balance and proprioception.

The lower extremity comprised 61.5 % of the total injuries and spine comprised 20.2 % of the total injuries that occurred with the national field hockey team. Injuries in the lower extremity revealed by this study, such as stress syndromes, non-acute muscle strains, and tendinitis, are common overuse injuries in running sports (Arnheim, 1997; Bierhals, Gorse & Mickey, 1997). Muscles that frequently suffer overuse injury include hamstrings, quadriceps, hip flexors, hip adductors and erector spinae (Arnheim; Geraci, 1998). The present study showed that the hamstrings and quadriceps were frequently injured. Strains occur from an interaction of warm up, strength, fatigue and flexibility and occur during or soon after a fatiguing game or practice (Cross & Worrell, 1999; Worrell, 1994). Muscular fatigue, a predisposing factor in the occurrence of muscle strain injury, significantly diminishes the ability of muscle to absorb energy before failure (Bachman Neilson et al., 1999; Garrett, Glisson, Mair & Seaber, 1996). From the previous discussion, muscular fatigue occurs in sports, such as field hockey, that require prolonged running and repetitive lifting movements. Proper conditioning to avoid fatigue and exercise modification when fatigue occurs will help prevent muscle strain (Garrett et al., 1996).

Sports activity can overload the musculoskeletal system in predictable ways. Every sport has movement patterns that are repeated throughout the game. These repetitive movement patterns will inherently tighten and strengthen some muscles and lengthen and weaken other muscles (Fieseler et al., 1997). Muscle imbalance is an abnormal difference in the length and strength of agonist and antagonist muscles that occurs from a variety of muscle tightness and weakness (Vincenzino & Vincenzino, 1995). When evaluating the role of muscle imbalance in injury in field hockey, one must consider both imbalances in the back and lower extremity due to bending, twisting and running.

Support of the back and pelvis are provided in part through muscles. Herring and Kaul (1998) stated that the thoracolumbar fascia has attachments to the internal obliques, the transversus abdominus and the latissimus dorsi. When these muscles are contracted, the thoracolumbar fascia is tightened and trunk flexion is resisted. Contraction of the abdominal muscles also engages the hamstring and gluteal muscles, causing a posterior pelvic tilt, which further tightens the thoracolumbar fascia. The paraspinal muscles add further stability to the low back and pelvis. The erector spinae, multifidi, longissimus and iliocostalis muscles provide stabilization in axial rotation and lateral flexion. The iliopsoas counteracts the pull of the spinal extensors and also stabilizes the spine in lateral flexion and rotation (Herring & Kaul, 1998).

The stability of the low back and pelvis provides an important control of the bending and twisting that occurs during running and skill performance in field hockey. Dananberg (1997) stated that running gait is maintained through the inertia of the swing limb, powered by the storage of potential energy and the return of kinetic energy by the ligaments, tendons and muscles of the low back, which carries the body's center of gravity forward over the weight bearing limb. At toe off, the iliopsoas contracts to swing the leg forward. This swing is propelled by the ligaments of the lumbar spine and gluteus maximus via the thoracolumbar fascia and latissimus dorsi. If a stable base in the low back is not present, the body must compensate through overuse of the contralateral quadratus lumborum, gluteus maximus and ilitibial band complex. This overuse leads to subtle repetitive strain injury (Dananberg).

The pelvis is the link in transmission of forces between the trunk and lower extremities (Geraci, 1998). Changes in muscle strength and flexibility will affect the way the body is propelled during running. Changes in muscle use to compensate for weak, lengthened or tight muscles will lead to subtle repetitive trauma on joints and other muscles. Muscle imbalance around the pelvis can lead to chronic injury. Weak abdominals and tight iliopsoas, rectus femoris or thoracolumbar fascia can inhibit gluteus maximus and create an anterior pelvic tilt (Geraci; Herring & Kaul, 1998). This pelvic position increases the lumbar lordosis and the stress on the lowest two lumbar discs, facet joints and sacroiliac joints. An anterior pelvic tilt lengthens the hamstrings and gluteals putting them at a mechanical disadvantage and leading to early recruitment of the lumbar extensors (Geraci; Herring & Kaul). The early use of lumbar extensors causes not only shear in the lumbar spine, but also increases the degree of knee flexion at heel strike leading to an increased risk for patellar tendinitis and patellofemoral syndrome (Geraci; Herring & Kaul). A weak or inhibited gluteus medius and minimus coupled with tight adductors lead to an excessive lateral tilt of the pelvis (Geraci). This excessive tilt increases the use of the thoracolumbar fascia and increases the tightness of lateral knee structures (Geraci). Piriformis can become overloaded when it tries to substitute for an inhibited gluteus medius (Geraci). A tight piriformis can lead to torsional movements of the sacrum (Geraci). Tight hip rotators increases the stress to the sacroiliac joints, discs and extensor muscle attachments (Herring & Kaul). Weak paraspinals or tight gluteals and hamstrings create a posterior pelvic tilt (Herring & Kaul). This pelvic position inherently lengthens the hip flexors and back extensors and decreases the lumbar lordosis (Herring & Kaul). To avoid these injuries, muscle balance through improvement of flexibility, strength and endurance must be attained.

Muscle imbalances can also result from constant bending and twisting. Muscle work and spinal loading from running for the majority of a 70 minute field hockey game in varying degrees of trunk flexion places high demands on the back extensors for endurance and eccentric and concentric strength (Fenety & Kumar, 1992). No studies currently exist on the biomechanics of field hockey or on the relation of injuries to the biomechanics of the sport. However, information regarding the potential for injury in rowing can provide some insight. The biomechanics of the rowing stroke, its intensive demand on the lumbar spine and sacroiliac joint and its repetitive motion result in overuse injuries (Allen & Jones, 1998; Timm, 1999). The highest demands on the lumbar spine occur in the catch and drive portions of the rowing stroke (Timm). The catch occurs as the oars enter the water and the rower's hips, knees and lumbar spine are maximally flexed (Timm). The drive follows and consists of rapid extension of the knees, hips and lumbar spine coupled, in sculling, with spinal rotation (Timm). Field hockey also requires knee, hip and lumbar spine extension with rotation when the player moves from a passing or receiving position to a more upright running position. The muscle imbalances that have the potential to occur in field hockey, due to the sport's running nature, can also occur in rowing. Tight hip flexors coupled with weak abdominals cause the pelvis to rotate anteriorly increasing lumbar lordosis and placing increased stress on the lumbar spine, ligaments and muscles (Allen & Jones). Hamstring tightness may cause limited rotation of the pelvis resulting in excessive stretch of low back structures, including posterior ligaments and extensor muscles, and joint degeneration (Allen & Jones). Sacroiliac joint dysfunction can occur as a result of these lower extremity muscle imbalances (Allen & Jones; Timm). Although the pull in rowing requires a greater force than field hockey, the repetition of the extending and twisting movement is the same as field hockey. Development of muscle endurance is essential and may reduce the risk of overuse injury (Allen & Jones; Lee, 1997).

From this discussion, it becomes apparent that to decrease the incidence of chronic injury a number of areas need to be addressed. Muscular fatigue is often cited as being a cause of chronic injury. Coordination, balance and proprioception in the lumbar spine have all been shown to decrease with fatigue. Poor warm up, strength and flexibility have all been discussed as contributors to muscle strain. Muscle imbalances can subtly alter force distribution throughout the body and can leave certain structures susceptible to injury. Strength, balance, proprioception and coordination training and postural stability of the pelvis have been shown to be components of a successful treatment regimen for chronic injury (Bachman Nielson et al., 1999; Fieseler et al., 1997; Geraci, 1998). The current national team training program addresses some, but not all, of these factors.

Strengthening has been a component of the training program for years and is performed predominantly in periods of non-centralized training. Prior to the centralization studied, the strengthening program included 3 to 6 sets of 6 to 10 repetitions at 70 to 85 % of a one repetition maximum of the following exercises: incline bench press, leg press, lat pulldowns, leg curls, shoulder press, shoulder fly's, arm curls, tricep extensions, seated row, dumbbell rows, wrist curls, hip adduction and hip abduction. The primary and secondary muscles used in each exercise is shown in Appendix F. These exercises emphasized upper body strength and strength in basic lower body movement patterns, and were designed to prevent Canadian players being "pushed off the ball" in competition. From studies on field hockey and sports related to field hockey, it is apparent that many chronic injuries result from fatigue and muscle imbalance about the pelvis and low back. Considering the nature of many of the injuries revealed by the present study, and if the purpose of the strength training program was also to prevent injury, some areas were neglected in the strengthening program. Firstly, there were no specific exercises for the flexors and rotators of the hip or for the rotators, side flexors and extensors of the back. Pulley exercises for both the hips and back and back extensions are examples of exercises that would target these muscle groups (Wathan, 1994). Secondly, a balanced exercise program should include a diverse set of strength and endurance exercises (Herring & Kaul, 1998; Parnianpour et al., 1997). No strength or endurance exercises were performed for muscles around the pelvis and very little muscular endurance work for any muscle group was ever done. Fenety and Kumar (1992), in their study on low back pain in field hockey, concluded that any field hockey training program should include tonic and endurance strengthening of all the muscles that support the trunk. The introduction of strength exercises for the trunk and muscular endurance exercises for all muscles in the period prior to high intensity centralized training would be valuable in the prevention of injury.

Sport specificity in strength training is also important. Sport specific exercises not only improve muscular strength but also mimic the coordination, balance and proprioception required by the sport. The lower extremity strengthening exercises could have been more sport specific to the body position seen in field hockey. Exercises such as leg press position the feet side by side and do not challenge balance (Keogh, 1999). However, exercises that target one leg over the other are advantageous in sports, like soccer, where the athlete has to change directions frequently (Chandler, 1998). One of the basic positions in field hockey for defending and receiving and passing the ball is the split stance, where one foot is diagonally placed ahead of the other foot. A split position is also seen in running when one limb approaches heel strike while the other limb has just completed toe off. Performance of activities where the feet are close together does not reproduce the basic position or movements of field hockey. Performing exercises in a split stance has many benefits. The split stance imposes a greater proprioceptive demand than the side by side stance, helps to develop dynamic stability throughout the lower body and torso, increases balance from external perturbations and improves dynamic flexibility in the ankle hip and knee joints (Keogh). Exercises that alternate the split stance from leg to leg, such as forward and reverse lunge walking, angled forward lunge walking, lateral lunges and step ups all eccentrically challenge the hip flexors, extensors, adductors and abductors, help the athlete with rapid changes in direction and increase proprioceptive demands (Keogh). Substituting split stance exercises, such as lunges or step ups, for leg press would meet the goal of the current weight-training program and more specifically address sport specificity for the lower kinetic chain in strength, coordination of movement, balance, proprioception and the prevention of injury.

Core stability exercises ("body control") were introduced to centralized training three years prior to this study and were usually performed at the beginning of each morning practice. The purpose of these body weight and body ball exercises was to build trunk stability, coordination, balance and proprioception. Strength training and core stabilization training both challenge the stabilizing muscles of the spine, but they do so differently. Strength training challenges large muscle groups, such as the paraspinals, gluteals, hamstrings and quadriceps, through the use of a large resistance to address deficits in strength and endurance (Arnheim, 1997; Hyman & Liebenson, 1996). The athlete must balance the resistance while performing the exercise which, when performed properly, will also challenge the stabilization of the spine. Body control exercises train the stabilizers of the trunk, such as multifidus, gluteus maximus and the external obliques, both through low resistance repetition, which is often too low to achieve a strengthening effect, and challenges to neuromuscular coordination (Hyman & Liebenson). Neuromuscular coordination involves contracting the appropriate muscles, with optimal timing and force, to produce a movement where the pelvis and lumbar spine maintain a neutral position (Arnheim, 1997; Posner-Mayer, 1995). Unlike traditional strengthening exercises, body control exercises are performed under constantly changing conditions and on labile surfaces. These changing conditions and surfaces promote flexibility in motor strategies because the body must find numerous ways to successfully complete the activity while maintaining a neutral trunk position (Posner-Mayer). According to this rationale, the addition of these exercises to the training regimen represented an important step in providing both trunk strength and injury prevention. However, body control could be improved in two ways. Firstly, athletes rarely continued core stability exercises outside of centralized training. As with the strengthening program, preventive strength and endurance exercises need to be performed throughout the year. Secondly, fatigue of stability muscles has been cited as contributing to chronic injury in the lumbar spine, pelvis and lower extremity. Performing body control before practice trains the stability muscles in a non-fatigued state. As with training on labile surfaces, training at different stages of fatigue would also challenge the body to create flexible motor strategies. Consequently, it would be advantageous to train core stability with the body in a fatigued state. Body control should be performed both before and after practices, when the body would be in different states of fatigue.

In addition to the high incidence of chronic injury, recurrent injury comprised 33.9 % of the total number of injuries. This percent of recurrent injury suggests that while some athletes became pain-free and were able to return to participation, their injuries never completely healed. This observation is supported by current knowledge on tissue healing. Arnheim (1997) describes three phases of healing. The acute phase occurs over the first three to four days following an injury. The body attempts to control inflammation and clean up the cellular debris in the injured tissue. The repair phase occurs from two days to six weeks. Fibroblastic activity promotes collagen deposition to replace the injured tissue with scar or to regenerate the injured tissue. The remodeling phase begins three to six weeks after injury and continues as long as three months to two years. Collagen content and tensile strength increase in relation to the stresses placed through the tissue during this stage (Arnheim). In the case of injury, a complete rehabilitation program must be followed to decrease the chance of recurrent injury. However, during centralized training, it is difficult to completely rehabilitate any injury for a number of reasons. Firstly, the length of centralized training is often not as long as the length of time required for complete tissue healing. Secondly, even though the head coach advocates rest for injured athletes, athletes are very reluctant to take time off from training and competition. Thirdly, once the centralization has ended, athletes return to their home cities and may not continue to have their injuries treated. Athletes should be reminded that they should follow a complete rehabilitation program both during and following centralized training.

Sport specific agility, speed and skill drills, such as plyometrics, interactive eccentric and concentric muscle loading, anaerobic sprints, and interval training, coordinate interaction of the athlete's antagonistic and supporting muscles and are the final component of a chronic injury rehabilitation program (Fieseler et al., 1997). These areas were addressed very well in the national team training program. Agility, speed and skill drills were a part of every practice. Plyometrics, including bounding and medicine ball exercises, and strength training were performed one time per week when the team was not in competition. Anaerobic training was incorporated into the daily skill training drills and also accomplished through separate sprint practices which occurred once per week when the team was not in competition. Outside of practice, the athletes performed interval training one to two times per week, depending on the competition schedule.

Warm up, usually consisting of running and stretching, is another important aspect of injury prevention. The muscle contraction of low intensity running increases muscle temperature and the extensibility of collagenous tissue (Garrett, Glisson, Ribbeck, Safran & Seaber, 1988). Static cyclic stretching leads to a decrease in force placed upon the musculotendinous junction through the required areas of motion (Cross & Worrell, 1999). Warm up stretches the musculotendinous unit and results in an increased length at a given load, resulting in reduced incidence of injury to the musculotendinous junction (Garrett et al.). The national team performed a comprehensive warm up prior to each practice and game. Each athlete performed 5 to 10 min of light jogging followed by 20 min of static stretching. The entire group then performed 5 to 10 min of hopping, skipping, bounding, speed and footwork drills over 25 to 50 m. In practice, this warm up would be generally be followed by hitting and receiving drills and in games, by a 20 min stick and ball warm up.

Maintaining adequate flexibility in all muscle groups is another component of injury prevention. Muscle flexibility allows the muscle to accommodate to the stresses placed upon it by a particular movement (Zachazewsky, 1990). A number of different stretching techniques exist – static, progressive neuromuscular facilitation (PNF) and ballistic (Toomey, 1995; Zachazewsky). Static stretching involves the maintenance of a low intensity tension that does not stimulate the stretch reflex of the muscle but, rather, decreases muscle tension by holding a muscle at constant length (Toomey; Zachazewsky). PNF stretching uses alternating relaxation and contraction to maximize the inhibitory effects of the stretch reflex (Toomey). Ballistic stretches are active stretches performed at speed that allow the controlled practice of the available movement potential (Toomey). Flexibility includes both static and dynamic components (Zachazewsky). While both components refer to a muscle's ability to move through a specific range of motion, dynamic flexibility incorporates the ability of the muscle to move efficiently through its range at a high speed (Zachazewsky). To attain the greatest gains in flexibility, static, PNF and ballistic stretches should be used (Toomey). An effective stretching program begins with static and PNF stretches to attain flexibility changes in the muscle. These stretches are followed by ballistic stretching, emphasizing movement control and trunk stabilization, to increase neuromuscular coordination at the end of the new range of motion attained by static and PNF stretching (Toomey, Zachazewsky). Ballistic stretching must be performed carefully in order to avoid injury. Zachazewsky described a ballistic flexibility program in which the athlete progressed from slow movements which did not go completely to the end of the available range to fast movements which used the full available range. Progressions occurred over the course of days to weeks and the speed and range of motion used in each movement was dictated by the athlete. Just as core stabilization exercises that occur in changing conditions promoted the athlete to develop a variety of motor strategies to perform a specific task, this progression of ballistic stretching promoted the athlete to develop motor strategies to move efficiently and safely through the full range of motion at high velocities. The members of the national team emphasized passive and PNF stretching in their warm up. However, ballistic stretching was never performed. Coordination of movement has been shown to decrease with fatigue and this decrease in coordination is linked to injury. Ballistic stretching can increase neuromuscular coordination at the end of the range of motion of a given joint by systematically training the athlete to control movement at high velocities at the end of his or her available range of motion. Consequently, its addition to the prepractice and pregame warm up would be prudent.

Repetitive movement is linked to chronic injury. In centralized training, players practice two to four hours per day in addition to their running training. Bierhals et al. (1997) investigated the effect of completing football cardiovascular conditioning through crosstraining rather than running on turf. They found a decrease in overuse injury in those athletes that performed crosstraining (Bierhals et al.). The national team coach recognized crosstraining as a viable alternative to running training for athletes with injuries. However, the findings of Bierhals et al. suggest that in times of intensive centralized training, crosstraining for at least one running workout per week should be employed, regardless of the athlete's injury status. Members of the national team completed two to three running workouts and one crosstrain or fartlek per week of centralized training, depending on the competition schedule. One crosstrain should be substituted for one running workout per week during centralized training.

Evaluating the athlete for potential muscle imbalances and correcting these imbalances is another important step in the prevention of injury. Theoretically, a high risk for muscle imbalance exists in field hockey players. However, no research has been done in this area. Based upon literature for other sports, preseason screening of athletes for muscle imbalances and adaptation of training programs to combat these potential imbalances should be performed. This screening process did not occur prior to nor during the centralization. An evaluation of potential muscle imbalances for each athlete should occur at least once per year.

5.6 Mechanical Stress

In the present study, injuries due to mechanical stress occurred most frequently in the first half of play. This is an unusual finding. These injuries are more usually expected as the game progresses and fatigue sets in. Injuries early in the game suggest the possibility of another mechanism. It is possible that this mechanism may relate to coordination, balance and warm up.

Studies on the rehabilitation of lower extremity joint strains stress the importance of coordination and balance training (Askling, Gillquist & Tropp, 1985; Odenrick & Trop, 1988). It is possible that decreased coordination and balance may have affected the occurrence of the mechanical stress injuries seen in the present study. The importance of training coordination and balance in the prevention of overuse injury has already been discussed. It is possible that coordination and balance were not adequately addressed in the warm up and, consequently, the athletes were not prepared for the stress presented to them during the first half of play.

As previously stated, the athletes in the present study performed a rigorous running and stretching warm up. However, while static and PNF stretching will increase muscle flexibility, they will not increase neuromuscular coordination at the extremes of the range of motion at high velocities (Garrett, 1996; Toomey, 1995; Zachazewsky, 1990). Coordination and balance could be warmed up by adding ballistic stretching and balance challenging exercises into the pregame preparation.

Another possible method of sensitizing coordination and balance prior to a game is to perform a precompetition strength training session. A precompetition strength training session gives the benefits of strength training and warm up by increasing neural activation and increasing motor recruitment and synchronization (Decker, Fees, Mehdi & Zantz, 1998). Incorporating resistance training into pregame preparation is designed to warm up specific joints and muscles by mimicking the gross and fine motor patterns of a particular sport (Decker et al.). The program should be a low volume of 10 to 15 repetitions performed at 50 to 60 % of the one repetition maximum (Decker et al.). The program should include abdominals and low back exercises, core resistance exercises, and push-pull leg exercises with static and ballistic stretching (Decker et al.). Typically when games were played at 2 and 4 o'clock in the afternoon, the national team performed a light jog and stretch at approximately 9 o'clock in the morning. A few body weight, coordination and balance challenging exercises could be incorporated into this early "wake and stretch" session.

5.7 Contact Injuries

In the present study, contact injuries from the ball and stick occurred with increasing frequency as the game progressed. Generally, these types of contact injuries are related to poor technique. To be hit by the ball other than on the foot, the ball has to be raised off the ground. Raising the ball in a dangerous manner is contrary to the rules. Being hit by the stick involves either an uncontrolled swing by the player wielding the stick or poor positioning by the player hit. The pattern of injury shown in the present study suggests that as the game progressed, fatigue increased and ability to properly perform skills decreased. Players should be made aware that there is an increased risk of injury from contact as the game progresses. They should also practice skills late in practices in order to train themselves to maintain a high level of skill regardless of fatigue. The latter occurred with the national team. Drills that required a high level of accuracy and skill were frequently performed late in the practice when the athletes were most fatigued.

In the study on the national field hockey team, the ratio of ball or stick contact injury to player or ground contact injury was 3:1 for field players and 0.5:1 for goalies. Field players suffered more ball or stick contact injuries than goalies, that lead predominantly to contusions (10) and lacerations (2). The majority of areas injured through contact of field players were areas where there was no protective equipment. Players need either to accept this pattern of injury as an inherent danger of field hockey or players need to wear much more protective equipment than shin guards and mouth guards.

Goalies were injured from ground and player contact more than from ball and stick contact. Unlike any other sport, field hockey goalies have to come in deliberate contact with the ground and other players (Fox, 1981). A common technique to stop the ball is to "slide". This technique involves sliding, usually along one hip, directly at the ball carrier to strip the ball from her. It is difficult to tell whether the body and ground contact injuries demonstrated in the present study occurred as a result of poor technique or whether the accepted technique places goalies at an increased risk over field players for this type of injury.

5.8 Summary

There are few studies on field hockey. In order to discuss the patterns and nature of the injuries of the national field hockey team, comparisons must be made to sports with similar components. Hurling, soccer and rowing provide some insight.

The incidence of injury in field hockey games was similar to the findings of injury studies in hurling and soccer, but the incidence of injury in field hockey practices was much higher. Chronic injuries occurred most frequently in practices. Rowing studies show a similar incidence of chronic injury in practice.

A consistent peak in the frequency of injuries occurred near the midpoint of each section of centralization.

The types of injury found in the present study were similar to the types of injuries found in other field hockey, hurling and soccer studies. The frequency of lower extremity injuries in field hockey was similar to soccer. The frequency of injuries to the spine was more similar to rowing than to soccer.

The present study found a slightly higher incidence of injuries of moderate severity than soccer studies. This difference can be explained by the higher percentage of chronic injury in field hockey.

As with hurling and soccer studies, playing position, area of the pitch, weather conditions and turf temperature did not affect the frequency of injury.

The identification of areas where preventive measures may be required was a goal of the present study. Chronic injury can arise from a combination of repetitive movements superimposed on fatigued and imbalanced muscles. The running nature of field hockey, combined with its repetitive bending and twisting, makes it a sport that theoretically is susceptible to overuse injuries.

The training program for the national team was developed predominantly for maximizing athletes' playing potential. The addition of a few components would improve both this goal of the program and injury prevention. Strength and muscular endurance exercises to muscle groups responsible for trunk stability should be incorporated into the precentralization weight training program. Exercises incorporating the split stance would increase strength, coordination, balance and proprioception in a sport specific fashion. Body control exercises should be performed throughout the year with the athletes in various stages of fatigue. Ballistic stretching and exercises that challenge balance and proprioception should be incorporated into prepractice and pregame preparation.

Athletes should be screened for muscle imbalances prior to the beginning of centralized training and adaptations to their training programs should be made to address any areas of potential injury.

Should an athlete become injured, she should be encouraged to complete rehabilitation of the injury both during and following periods of centralization.

Athletes should be made aware of the potential for ball and stick contact injuries as their fatigue levels increase. Sliding technique in goalies should be evaluated to ascertain whether the body and ground contact injuries goalies sustain are a result of poor technique or simply a function of the position.

5.9 References

Alexander K. and Kinney LaPier, T. (1998). Differences in static balance and weight distribution between normal subjects and subjects with chronic unilateral low back pain. Journal of Orthopaedic and Sports Physiotherapy,

Allen, K. and Jones, M. (1998). Sport-specific conditioning to prevent injuries in rowing. Strength and Conditioning, 20(1), 35 – 39.

Arnheim, D. and Prentice, W. (1997). Principles of athletic training. United States of America: McGraw-Hill Companies, Incorporated.

Askling, C., Gillquist, J. and Tropp, H. (1985). Prevention of ankle sprains. The American Journal of Sports Medicine, 13(4), 259 – 262.

Bachman Nielson, M., Holmich, P., Kanstrup, I., Krogsgaard, K., Munch Berg, A., Uhrskou, P. and Ulnits, L. (1999). Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: Randomized trial. The Lancet, 353(9151), 439 – 443.

Bauman, C., Harris, J., Jones, B., and Knapik, J. (1992). Strength, flexibility and athletic injuries. Sports Medicine, 14(5), 277 – 288.

Bierhals, A., Gorse, K. and Mickey, C. (1997). Conditioning injuries associated with artificial turf in two preseason football training programs. Journal of Athletic Training, 32(4), 304 – 308.

Bol, E., Inklaar, H., Mosterd, W. and Schmikli, S. (1996). Injuries in male soccer players: Team risk analysis. International Journal of Sports Medicine, 17(3), 229 – 234.

Chandler, J. (1998). In Herring, S., Kibler, W. and Press, J. (Eds.), Functional Rehabilitation of Sports and Musculoskeletal Injuries, Gaithersburg, Maryland: Aspen Publishers, Incorporated, 98 - 108.

Cross, K. and Worrell, T. (1999). Effects of a static stretching program on the incidence of lower extremity musculotendinous strains. Journal of Athletic Training, 34(1), 11 – 14.

Cunningham, C. and Cunningham, S (1996). Injury surveillance at a national multisport event. The Australian Journal of Science and Medicine in Sport, 28(2), 50 – 56.

Dananberg, H. (1997). Lower back pain as a gait related repetitive motion injury. In Dorman, T., Mooney, V., Snijders, C., Stoeckart, R. and Vleeming, A. (Eds.), Movement, Stability and Low Back Pain: The Essential Role of the Pelvis, New York: Churchill Livingstone, 253 – 267.

Decker, A., Fees, M., Mehdi, O. and Zantz, C. (1998). Incorporating resistance training into the precompetition warm-up. Strength and Conditioning, 20(4), 51 – 53.

Ekstrand, J. and Gillquist, J. (1983). Soccer injuries and their mechanisms: A prospective study. Medicine and Science in Sports and Exercise, 15(3), 267 – 270.

Ekstrand, J. and Gillquist, J. (1983b). The avoidability of soccer injuries. International Journal of Sports Medicine, 4(1), 124 – 128.

Engstrom, B., Johansson, C. and Tornkvist, H. (1991). Soccer injuries among elite female players. The American Journal of Sports Medicine, 19(4), 372 – 375.

Fenety, A. and Kumar, S. (1992). Isokinetic trunk strength and lumbosacral range of motion in elite female field hockey players reporting low back pain. Journal of Orthopaedic and Sports Physical Therapy, 16(3), 129 – 135.

Fieseler, C., Howard, T., Nirschl, R., and O'Connor, F. (1997). Managing overuse injuries. The Physician and Sports Medicine, 25(5), 88 – 113.

Fox, N. (1981) Risks in field hockey. In T. Reilly (Ed.), Sports fitness and sports injuries. Boston: Faber and Faber, 112 – 117.

Fricker, P., Hickey, G. and McDonald, W. (1997). Injuries to elite rowers over a 10-year period. Medicine and Science in Sports and Exercise, 29(12), 1567 – 1572.

Fuller, C. and Hawkins, R. (1998). An examination of the frequency and severity of injuries and incidents at three levels of professional football. British Journal of Sports Medicine, 32(4), 326 – 332.

Garrett, W. (1996). Muscle strain injuries. The American Journal of Sports Medicine, 24(6), S-2 – S-8.

Garrett, W., Glisson, R., Mair, S. and Seaber, A. (1996). The role of fatigue in susceptibility to acute muscle strain injury. The American Journal of Sports Medicine, 24(2), 137 –143.

Garrett, W., Glisson, R., Ribbeck, B., Safran, M. and Seaber , A. (1988). The role of warmup in muscular injury prevention. The American Journal Of Sports Medicine, 16(2), 123 – 128.

Geraci, M. (1998). Rehabilitation of the hip, pelvis and thigh. In Herring, S., Kibler, W. and Press, J. (Eds.), Functional Rehabilitation of Sports and Musculoskeletal Injuries, Gaithersburg, Maryland: Aspen Publishers, Incorporated, 216 – 243.

Glace, B., Gleim, G. and McHugh, M. (1998). Effects of a 2-hour run on metabolic economy and lower extremity strength in men and women. Journal of Orthopaedic and Sports Physical Therapy, 27(3), 189 – 196.

Hendy, M., Lindenfield, T., Mangine, R. Noyes, F. and Schmitt, D. (1994). Incidence of injury in indoor soccer. The American Journal of Sports Medicine, 22(3), 364 – 371.

Herring, S. and Kaul, M. (1998). Rehabilitation of lumbar spine injuries. In, Herring, S., Kibler, W. and Press, J. (Eds.), Functional Rehabilitation of Sports and Musculoskeletal Injuries, Gaithersburg, Maryland: Aspen Publishers, Incorporated, 188 – 215.

Hyman, J. and Liebenson, C. (1996). Spinal stabilization exercise program. In, Liebenson, C. (Ed), Rehabilitation of the Spine: A Practitioner's Manual, Philadelphia: Williams and Wilkins, 293 – 317.

Inklaar, H. (1994). Soccer injures I: Incidence and severity. Sports Medicine, 18(1), 55 – 73.

Jamison, S. and Lee, C. (1989). The incidence of female hockey injuries on grass and synthetic playing surfaces. The Australian Journal of Science and Medicine in Sport, 21(2), 15 – 17.

Jull, G., Lam S. and Treleaven, J. (1999). Lumbar spine kinesthesia in patients with low back pain. Journal of Orthopaedic and Sports Physical Therapy, 29(5), 294 – 299.

Keogh, J. (1999). Lower body resistance training: Increasing functional performance with lunges. Strength and Conditioning, 21(1), 67 –72.

Odenrick, P. and Trop, H. (1988). Postural control in single limb stance. Journal of Orthopaedic Research, 6(6), 833 – 839.

Parnianpour, M., Reinsel, T., Simon, S. and Sparto, P. (1997). The effect of fatigue on multijoint kinematics, coordination, and postural stability during a repetitive lifting test. Journal of Orthopaedic and Sports Physical Therapy, 25(1), 3 – 12.

Posner-Mayer, J. (1995). Swiss Ball Applications for Orthopaedic and Sports Medicine, Denver: Ball Dynamics International, Incorporated.

Reilly, T. and Seaton, A. (1990). Physiological strain unique to field hockey. The Journal of Sports Medicine and Physical Fitness, 30(2), 142 – 146.

Rose, C. (1981). Injuries in women's field hockey: A four year study. The Physician and Sports Medicine, 9(3), 97 – 100.

Singh, A. and Williams, C. (1997). Dynamic trunk strength of Canadian football players, soccer players, and middle to long distance runners. Journal of Orthopaedic and Sports Physical Therapy, 25(4), 271 – 276.

Timm, K. (1999). Sacroiliac joint dysfunction in elite rowers. Journal of Orthopaedic and Sports Physical Therapy, 29(5), 288 – 293.

Toomey, M. (1995). The pelvis, hip and thigh. In Briggs C., Carlisle, J., McDonald, V., McMeeken, J., Nickson, J., Wilson, D. and Zulaga, M. (Eds.), Sports Physiotherapy: Applied Science and Practice, Melbourne: Churchill Livingstone, 507 – 539.

Vincenzo, B. and Vincenzo, D. (1995). Prevention of injury. In Briggs C., Carlisle, J., McDonald, V., McMeeken, J., Nickson, J., Wilson, D. and Zulaga, M. (Eds.), Sports Physiotherapy: Applied Science and Practice, Melbourne: Churchill Livingstone, 95 – 116.

Wathan, D. (1994). Exercise selection. In Baechle, T. (Ed.), Essentials of Strength Training and Conditioning, Champaign, Illinois: Human Kinetics, 416 – 423.

Watson, A. (1996). Sports injuries in the game of hurling: A one-year prospective study. The American Journal of Sports Medicine, 24(3), 323 – 328.

Whitney, S. (1983). World cup hockey. Physiotherapy, 69(11), 390 – 392.

Worrell, T. (1994). Factors associated with hamstring injuries: An approach to treatment preventative measures. Sports Medicine, 17(5), 338 – 345.

Zachazewsky, J. (1990). Flexibility for sports. In Saunders, B., (Ed.), Sports Physical Therapy, Norwalk, Connecticut: Appleton and Lange, 201 – 238.

CHAPTER 6

Summary, Conclusions and Recommendations

6.1 Summary

Safe participation in sporting activity and performance enhancement are two important components of sport medicine. While field hockey has the potential for many injuries, few studies on field hockey have been undertaken. The present study performed an indepth investigation of the Canadian women's national field hockey team from April 26 to August 8, 1999. The purpose of the study was to identify the patterns and nature of injuries in elite women's field hockey, to identify the extrinsic risk factors associated with these injuries, to provide the basis for preventive measures to reduce these injuries and to identify directions for future research.

The present study used an adaptation of the Canadian Intercollegiate Sport Injury Registry (Meeuwisse & Love, 1998), in a prospective observational cohort research design. Subjects were members of the Canadian women's national field hockey squad who participated in centralized training prior to the 1999 Pan American Games and those members who were selected from the training squad to participate in the 1999 Pan American Games.

Data were collected on each participant through three methods. The first method required the athlete to complete a questionnaire on previous injuries, with specific reference to back injuries, concussions and the use of braces or tape. The second method required the researcher to document by session the amount of exposure to activity for each athlete, including a session description, field and weather conditions, field (turf) and air temperatures and humidity. The third method required the researcher to complete an injury report form for each injury brought to the attention of the researcher.

The major findings of this study include the following.

1. The incidence of injury was 0.034 injuries per hour.
2. Each section of centralization had a peak of injury frequency near the midpoint and a sub-peak of injury frequency near the beginning.
3. Chronic injuries, including fatigue, cramps and non-specific joint trauma (15.6 %), muscle strain (13.8 %), tendinitis (11 %) and postural mechanical dysfunction (11 %), occurred most frequently during skill training in practices.
4. Acute injuries caused by contact and mechanical stress, such as contusions (10.1 %), sprains (7.3 %) and traumatic mechanical dysfunction (6.4 %), occurred more frequently in games than in practices, and more frequently in the second half.
5. The majority of injuries were of moderate severity (58.7 %).
6. The lower extremity comprised 61.5 % of the total injuries and the spine comprised 20.2 % of the total injuries.
7. Left or right side of the body, history of previous injury, playing position, weather conditions and temperature, protective equipment and bracing or taping had no effect on frequency or severity of injuries.

6.2 Conclusions

The following conclusions can be made from the present study.

1. The nature and patterns of injuries sustained by the Canadian women's national field hockey team are outlined above. These data illustrate the extent of the injury problem

in field hockey and provide a basis to begin to develop preventive measures to reduce injury.

2. Extrinsic risk factors, such as left or right side of the body, history of previous injury, playing position, weather conditions and temperature, protective equipment and bracing or taping, did not effect the frequency or severity of injuries.
3. Potential areas for injury prevention relate to chronic injuries, injuries due to mechanical stress and injuries due to contact.
4. The lack of effect of extrinsic risk factors on injury and the theoretical basis for the causes of chronic and mechanical stress injury suggest that future research should be directed toward intrinsic causes of injury.

6.3 Recommendations

The following recommendations can be made regarding the present study and future research.

1. The Canadian Intercollegiate Sport Injury Registry was an excellent data collection tool for this study. However, two additions to this tool should be made. Entries regarding game injuries should indicate whether the injury occurred during free play or during penalty corners. Considering the high frequency of chronic injury found in this study, a question regarding whether or not the injury resolved during the period of the study should be added to the injury report form. This information would illustrate how many athletes were "playing injured".
2. In addition to the study documents, the researcher kept separate therapy notes on all the injuries. This process created a great deal of paperwork that, at times, was

difficult to complete. The injury report form should be incorporated into the charting process to decrease the time required for therapy charting.

3. While the data gathered by this study provides a picture of the injury problem in elite women's field hockey, some data analysis using the chi square test could not be completed because crosstabulation cell sizes were too small to satisfy the assumptions of the test. Injury data should continue to be collected during future periods of centralized training to provide a clearer picture.
4. The threshold used as the definition of injury and the definition of severity made comparison to other studies easy. This definition should continue to be used in the future.
5. A number of areas were identified as requiring future research. A measure of training intensity should be included in future data collection and related to the pattern of injury frequency. The biomechanics of field hockey and its relationship to injury, the potential existence of muscle imbalance in field hockey players and the relationship of these imbalances to injury, and the cause of contact injuries to goalies need further investigation.

6.4 References

Meeuwisse, W. and Love, E. (1998). Development, implementation and validation of the Canadian intercollegiate sport injury registry. Clinical Journal of Sport Medicine, 8(3), pp. 164 – 177.

APPENDIX A

Consent Form

CONSENT FORM

INJURY TRENDS OF THE CANADIAN WOMEN'S NATIONAL FIELD HOCKEY TEAM DURING PREPARATION FOR THE 1999 PAN AMERICAN GAMES

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The purpose of this study is to determine the incidence and severity of injuries that may occur during a period of centralized training by members of the Canadian women's national field hockey squad. Results obtained from this study will be used to fulfill the partial requirements of a Master of Science degree in the Faculty of Physical Education and Recreation at the University of Alberta.

Your participation will consist of:

1. filling out a questionnaire on your past injuries,
2. allowing your team therapist to record the amount of time you participate in practices and games,
3. allowing your team therapist to fill out an injury report form, which is separate from your national team therapy notes, if you become injured, and
4. allowing your team therapist to contact you after you have finished training with the national team if the documentation of your injury is incomplete.

Your participation in this study is completely voluntary. Your decision to participate will have no bearing on your selection to the Pan American Games team or on any medical care you may need.

If you agree to participate, your name will be randomly assigned a number and only this number will appear on any injury records. All information collected will be stored in a locked container. Only the researcher will have access to this information. Raw data collected from this study will be kept for five years following publication of the results. Following this period, the data will be destroyed.

You will be asked to commit ten minutes to complete the questionnaire. Any other information collected will be done as part of your normal medical care, and will not require any more time on your part.

Verbal information regarding the nature and severity of any injury sustained by an athlete will be given to the coach in order to provide a safe training environment for the athlete. This information could be considered for selection to the Pan American Games team. An athlete can refuse this transfer of information. The use of injury information for publishing results will not identify you by name. It may, however, be possible for persons familiar with your injury history to identify your injury.

Injuries will be reported as totals in categories of body areas, not by specific cases. This presentation will minimize the potential that you may be identified.

You may benefit from this research. Information provided by this study will note injury trends in women's field hockey and will provide the groundwork for an injury prevention program.

Your signature on this form shows that you have understood to your satisfaction the information regarding your participation in this research project and that you agree to participate as a subject. You may withdraw from this study at any time without consequence. Your withdrawal will not jeopardize your status on the team or your health care. Any data already collected on your injuries may also be withdrawn upon your request. To withdraw from the study and to withdraw your injury data, inform your team therapist.

You should remain informed about this study throughout your participation. If you have any questions or concerns related to this project or if you would like a copy of the final report, please contact Tija Westbrook at 780-438-7216 or tijaw@hotmail.com.

If you agree to be involved in this project, please indicate if you would **also** agree to be contacted at a later date if more information is needed:

___ YES, I agree to be contacted at a later date.

___ NO, I do not agree to be contacted at a later date.

You will receive a signed copy of this consent form.

The University of Alberta creates and collects information for the purposes of research and other activities directly related to its educational and research programs. All participants in research projects are advised that the information they provide, and any other information gathered for research projects, will be protected and used in compliance with Alberta's Freedom of Information and Protection of Privacy Act.

____
Name of athlete

____
Signature of athlete (or parent/guardian if under 18 years)

____
Name of investigator

____
Signature of investigator

____
Date

Adapted from Meeuwisse and Love, 1998

APPENDIX B

Questionnaire on History of Previous Injury

[redacted]

INJURY HISTORY

Last Name________________________________ First Name ________________________________

Date of Birth ____________________
Day/Month/Year

HEAD INJURIES / CONCUSSIONS

Have you ever had a concussion or been knocked out, had your "bell rung", or been "dinged"?

Please circle YES NO

If YES, please list:
the number of these injuries ____________, and specify:

Dates	Activity at the time	Length of Unconsciousness (minutes)	Length of time before full return to activity

Do you have any persistent problems with:

Memory YES NO Dizziness YES NO Headaches YES NO

BACK INJURIES

Have you ever had a low back, mid back, or neck injury? YES NO

If YES, please list:
the number of these injuries ____________, and specify:

Dates	Type of injury (low or mid back or neck)	Activity at the time	Length of time to recover

Please mark with * any back injuries that are **NOT YET HEALED.**

Do you routinely have any part of your body **taped** for field hockey? YES NO

If YES, please list ______________________________

Do you routinely wear any **braces** or **splints** for field hockey? YES NO

If YES, please list ______________________________

Have you ever suffered from heat stroke or heat exhaustion? YES NO

Check any of the areas that you have **INJURED IN THE PAST** and explain the injury below:

Hand _____	Elbow _____	Chest _____	Knee _____	Foot _____
Wrist _____	Arm _____	Hip _____	Shin/Calf _____	Face (including eye) _____
Forearm _____	Shoulder _____	Thigh _____	Ankle _____	Teeth _____

<u>Dates</u> <u>Type of Injury</u> <u>Side (Right/ Left/ Both)</u>

Are any of these injuries **NOT YET HEALED?** YES NO

If YES, which injury/injuries? ______________________________

____

Thank you again for your participation.

<u>Adapted from Meeuwisse and Love, 1998</u>

APPENDIX C

Exposure Sheet

Date (month/day)						
Session (game/practice/training)						
Duration (0.0 hrs.)						
Session Description (practice only) (i.e. walk through, set plays, scrimmage)						
Field Conditions (Dry/Wet)						
Weather (Sunny/Overcast/Rain/Strong wind)						
Humidity						
Temperature (Turf/Ambient in degrees Celcius)						

Participant Numbers												

Enter a participation code for each player indicating:

F	
P	
M	
0	

Full (> 75%)
Partial (75% - 25%)
Minimal (< 25%)
N0ne (0 %)

If athlete is not fully participating (i.e. coded "P", "M", or "0" above), indicate reason.

	I
	S
	A

Injured
Sick
Absent for any other reason

TOTAL EXPOSURE HOURS THIS SHEET

____

For time lost, total hours per
I__________
S__________
A__________

Adapted from Meeuwisse and Love, 1998

APPENDIX D

Injury Report Form

Participant Number ________

Date of injury (dd/mm/yy) ________________

Position played when injured (circle)

Forward / Midfield / Defense / Goalie / N/A

Injury Status:

___ New injury
___ Recurrence of injury from this centralization
___ Recurrence of injury prior to this centralization (field hockey)
___ Recurrence of non/other sport injury
___ Ongoing injury

Equipment (if applicable):

___ Was a mouthguard worn
___ Were shin guards worn
___ Other equipment worn

(describe) ________________________________

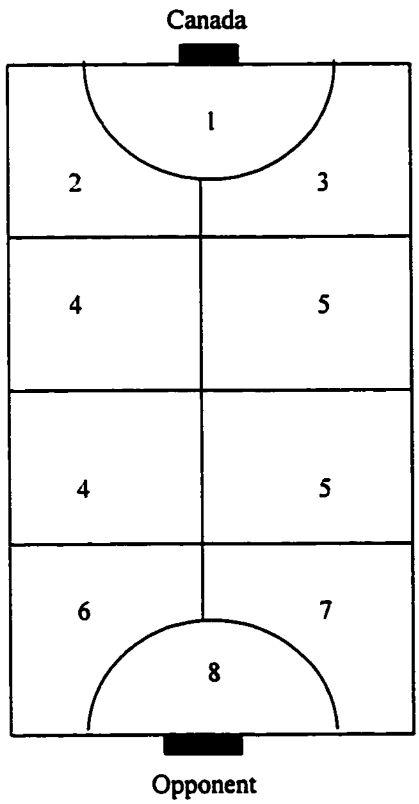
If goalie, list equipment worn ________________

____

____

Injury Zone (mark X)

OR ____ Not Applicable



Injury Conditions:

Game:
___ Morning
___ Afternoon
___ Evening
___ Warm Up
___ 1st Half
___ 2nd Half
___ Overtime
___ Strokes

Practice:
___ Morning
___ Afternoon
___ Evening
___ Warm Up
___ Skill Training
___ Scrimmage
___ Body Control

Other:
___ Weights
___ Cross Training
___ Conditioning
___ Other
(specify) ________________
___ Gradual Onset
___ Cause Unknown

Did the athlete **return to play** in the same session?

___ Yes ___ No ___ N/A

Was **bracing or taping** used on the area at the time of injury?

___ Yes (specify) ________________________________ ___ No

This injury involved:

Contact:

___ With Stick
___ With Ball
___ With Another Player
___ With the Ground
___ With the Goal Post

___ Mechanical Stress (e.g. plant, twist, stretch)

___ Overuse

Describe the **events surrounding injury** (including exact mechanism, if known): ___ Unknown

____
____
____
____

Remarks (subjective report of casue; e.g. unsafe play, hazardous conditions, poor surface):

____
____

Assessment:

____
Side (R/L/Both) Body Region and Structure Type of Injury ("Diagnosis")

Treatment/Follow-Up:

___ None
___ Tape/Brace
___ Pre-Game/Practice Stretch

Treatment:

___ Once/week; Home Program
___ > Once/week
___ Skin Closure

Physician/ Dentist Visit:

___ X-Ray; Bone Scan
___ Sutures
___ Specialist Referral
___ MRI; CT Scan
___ Surgery
___ Hospitalization

Estimate of time loss from injury (days): ___________

[redacted]

Adapted from Meeuwisse and Love, 1998

APPENDIX E

Original CISIR Forms for Football
(Reprinted with permission of Dr. W. Meeuwisse)

INJURY HISTORY QUESTIONNAIRE
1998/99

Canadian
Intercollegiate
Sport
Injury
Registry

To be completed by the athlete.

Last Name ______________________ First Name ______________________

Address ______________________ City ______________ Province ________

Date of Birth ____________ (Day Month Year) Home Phone # (____) ____________ Postal Code ________

Health Care # ______________________ Province ______________

FOR EMERGENCY NOTIFY: Name ______________________ Relationship ______________

Address ______________________ Phone ______________

Family Doctor's Name ______________________ Date of Last Physical ____________ (Month Year)

Sport ______________________

Year of Varsity Sport (circle): 1st 2nd 3rd 4th 5th 6th

Year of Eligibility (circle): None ("Red Shirt") 1st 2nd 3rd 4th 5th

. What position will you be playing this year? ____________

HEAD INJURIES / CONCUSSIONS:

		Yes	No
1.	Have you ever had a seizure?	❑	❑
2.	Have you ever had a head injury?	❑	❑
	Have you ever had a concussion or been "knocked out", had your "bell rung", or been "dinged"?	❑	❑

If YES, please list: Number: ______

Date(s)	Activity at the time	Length of unconsciousness (minutes)	Length of time before full return to activity

Did you have any persistent problems with:

Memory YES NO Dizziness YES NO Headaches YES NO

NECK INJURIES / BURNERS / STINGERS:

		Yes	No
3.	Have you ever had a neck injury (i.e. strain, sprain, fracture, etc.)	❑	❑
4.	Have you ever had a stinger, burner or pinched nerve? (a burning or numb feeling in the shoulder or arm after a hit to the head, neck or shoulder - aka. "brachial plexus stretch injury")	❑	❑

If YES, please list: Number: ______

Date(s)	Activity at the time	Length of time sensation/strength changes persisted?

5. Check any of the areas that you have INJURED IN THE PAST and explain the injury below:

Hand ___	Elbow ___	Neck ___	Hip ___	Shin/Calf ___
Wrist ___	Arm ___	Chest ___	Thigh ___	Ankle ___
Forearm ___	Shoulder ___	Back ___	Knee ___	Foot ___

Year of injury	Type of Injury	Side (right, left, both)	Is it still a problem? (Yes/No)

6. Do you have any incompletely healed injury? .... Yes ☐ No ☐

If yes, which injury? ______________________________

I hereby certify the above information to be correct.

Athlete Signature ______________________________ Date ______________

Injury History Summary

(To be completed by a P.T./Therapist).

Please summarize below the relevant injury information for the CISIR database and for your own records.

Athlete's Name: ______________________________

Problem Description	Side	Treatment	Date Active	Status *(eg. Active, Inactive, Recurrent, Ongoing, etc.)*	Date Inactive *(if appropriate)*

Date: ______________________ P.T. / Therapist: ______________________________

Canadian Intercollegiate Sport Injury Registry

Weekly Exposure Sheet

University: ________

Date (MM/DD)							
Session (Game/Practice)							
Duration (0.0 hours)							
Session Description (i.e. contact, running only, scrimmage, etc.)							
Field Type (Art/Nat)							
Field Conditions (Dry/Wet/Indoor)							
Weather (Sunny/Overcast/Rain/Snow)							
Recorder's Initials							

Athlete's Name	#														

Please enter a participation code for each player indicating:

⇓

F		Full (≥75%)
P		Partial (<75%)
O		or None (0)

If athlete is not fully participating (i.e. coded "P" or "O") please indicate if they are:

⇓

	I	Injured
	S	Sick, or
	A	Absent for any other reason

Canadian Intercollegiate Sport Injury Registry

Football

Individual Injury Report Form

1. Athlete Name: ____________________

2. Date of Injury: ____________________

3. Date Reported: ____________________

4. Position Played when Injured: ____________________
(note Offense or Defense)

5. Normal Position Played: ____________________

6. Injury Status:
- ☐ New injury
- ☐ Ongoing injury
- ☐ Recurrence of injury from this season
- ☐ Recurrence of injury from previous season (this sport)
- ☐ Recurrence of non/other sport injury

7. Was bracing or taping used on the injured area or limb at the time of injury?
- ☐ No
- ☐ Yes
  If so, what type?: ____________________

8. Did athlete return to play the same game or practice?
- ☐ No
- ☐ Yes

9. This Injury Involved:
- ☐ Hitting/Tackling
- ☐ Being Hit/Tackled
- ☐ Blocking
- ☐ Overuse
- ☐ Contact with: __________
- ☐ Unknown
- ☐ Other: __________

10. Injury Occurred During:
- ☐ Warm-up
- Practice:
  - ☐ First half of practice
  - ☐ Second half of practice
- ☐ Weight Training
- ☐ Other Conditioning
- ☐ Other Sport
- ☐ Non Sport
- ☐ Gradual Onset
- Game:
  - ☐ first quarter
  - ☐ second quarter
  - ☐ third quarter
  - ☐ fourth quarter
  - ☐ Overtime
  - (was game: ☐ Home ☐ Away?)
- ☐ Unknown

Describe Events Surrounding Injury (including exact mechanism of injury):

☐ Unknown ☐ Known: ____

____

____

____

Remarks: ____
(Subjective report of cause: e.g. unsafe action, illegal play, hazardous conditions, equipment, etc.)

Other Assessment Notes: ____

____

____

Assessment: ____

Side (Right/Left/Both) Body Region (and structure) Type of Injury ("Diagnosis") e.g. Right shoulder A/C joint 3° sprain

Treatment Plan (check all that apply):

- ☐ Protect
- ☐ Rest
- ☐ Ice
- ☐ Compression
- ☐ Elevation
- ☐ Stretch
- ☐ Strengthen
- ☐ Manual therapy
- ☐ Heat
- ☐ Modalities specify: ______
- ☐ Modify activity
- ☐ Observe
- ☐ Tape/Brace/Crutches (circle)
- ☐ Transfer to hospital
- ☐ Refer to physician

Other Treatment Notes: ____________________

____

____

____

____

Your Estimate of Time Loss from Injury (days): ______

Therapist's Name (print): ____________________

Therapist's Signature: ____________________

[redacted]

White - Therapist Copy *Yellow - C.I.S.I.R. Copy* *Pink - Physician Copy*

APPENDIX F

Primary and Secondary Muscles Used in Strengthening Exercises

Exercise	Primary Muscles	Secondary Muscles
Incline Bench Press	Pectoralis major Anterior deltoid Triceps	
Leg Press	Quadriceps Gluteus maximus	Hamstrings
Lat Pulldown	Latissimus dorsi	Brachialis Biceps brachii
Leg Curl	Hamstrings	Gastrocnemius
Shoulder Press	Deltoid Triceps	Upper trapezius
Shoulder Fly's	Posterior deltoid	Rhomboids Latisssimus dorsi
Arm Curls	Brachialis Biceps brachii	Wrist and finger flexors
Tricep Extensions	Triceps	Wrist and finger flexors
Seated Row	Rhomboids Middle trapezius	Posterior deltoid Brachialis Biceps brachii
Dumbbell Rows	Latissimus dorsi Rhomboids	Posterior deltoid Brachialis Biceps brachii
Wrist Curls	Wrist flexors and extensors	
Hip Adduction	Pectineus Adductor longus, magnus and brevis Gracilis	Hamstrings
Hip Abduction	Gluteus medius and minimus Tensor fascia lata	

Reference:

Wathan, D. (1994). Exercise selection. In Baechle, T., (Ed.), Essentials of Strength Training and Conditioning, Champaign, Illinois: Human Kinetics, 416 – 423.