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DISSERTATION ASSESSMENT PROFORMA:
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Comments	Section
	Title and Abstract (5%) Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.
	Introduction and literature review (25%) To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/ question; an indication of any research expectations, (i.e., hypotheses if applicable).
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CARDIFF METROPOLITAN UNIVERSITY
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CARDIFF SCHOOL OF SPORT

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Assessment of Playing Actions in Women's international soccer to determine injury risk/potential.

(Dissertation submitted under the Performance Analysis area)

Georgia Thomas

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Assessment of Playing Actions in Women's international soccer to determine injury risk/potential.

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Abstract

The main purpose of the study was to assess the playing actions within women's soccer to determine injury risk/potential throughout various time periods of match play. It was hypothesised that player-to-player contact actions would show a significant difference to all other playing actions as well as predicting that the last fifteen minute period of each half would possess the high risk of injury to the participant. 16 women's international soccer matches were observed and coded for the basis of analysis using Studio Code v5 software package (Sportstec, Australia). Information coded from the matches was exported into an Excel sheet and expressed as percentages for each playing action and time period. Results found that a total of 17 injuries occurred throughout the series of matches with tackling (35.3%) and receiving a tackle (23.5%) being major contributors of injuries. Significant differences between playing actions involving contact with the opposition and those that did not are shown throughout ($p<0.05$). The present study showed that the last fifteen minutes of each playing half possessed the highest injury risk (44.6% and 46.5%) with the second half of play showing a larger injury potential than that of the first. The results of the investigation present new information on injury risk within women's soccer providing a rationale for future research on injury in women's soccer based on the type and severity of injuries that occur.

CHAPTER I
INTRODUCTION

1.0 Introduction

Soccer; also known as the world's game is played by more than 120 million people worldwide (Longo et al., 2012). With soccer being a contact sport characterized by short, quick movements such as sudden acceleration and deceleration running phases, contact with opposing players and jumping and tackling movements, some level of injury risk is present (Rahnama et al., 2002, Longo et al., 2012, Carling et al., 2014).

1.1 Injuries within soccer

It is stated that, in comparison with other sports, soccer has a relatively high incidence of injury (Engstrom et al., 1991, Hawkins and Fuller, 1998, Rahnama et al., 2002, Rahnama, 2011, de Loes, 1995) particularly at stages of the game in which speed and intensity is increased (Inklaar, 1994, Inklaar et al., 1996, Hagglund et al, 2003, Ekstrand et al., 2004). This not only causes medical problems to sport medicine practitioners but also to the government finances estimating at around one billion pounds cost each year for soccer injuries alone (Tucker, 1997, Griffin et al., 2000, Rahnama et al., 2002, Murphy et al., 2003). It is also said that the direct cost associated with hospital in patient and outpatients care for sport and leisure injuries was estimated to be between £305,000 and £550,000 per 100,000 population a year (Junge and Dvorak, 2000). Because of the considerable medical expenses and taking into consideration the number of active football players in the world creating a high rate of injury incidence, it is stated that a prevention program to reduce the incidence of injury is urgently required (Junge and Dvorak, 2000, Schniff et al., 2010).

1.2 Playing actions in soccer

Several movements are carried out within soccer that do not lead to injury however hold some kind of potential injury risk dependent on the vigour and nature of the action in question. These actions are largely ignored in the literature even though they could be viewed as a potential factor for lower extremity injuries in the sport causing continuous occurrence of injury (Rahnama et al., 2002). Assessing these actions may provide a more detailed understanding of injury risk in the sport in order to determine when a player is more prone to these injuries. Therefore, the aim of the current study is to investigate the injury risk associated with playing actions during competitive women's soccer. Through this prevention programmes could be introduced to reduce the risk of injuries that occur.

1.3 Aims of the study

The role of playing actions in relation to injury risk has been scarcely investigated hence the importance to assess the injury risk involved with these actions along with period of play during women's soccer (Rahnama et al., 2002). For that reason the aim of the study is to assess the playing actions in women's soccer to determine the injury risk/potential. The hypotheses of the current study is:

- A significant differences between actions involving player to player contact and all other actions will be observed.
- The last 15 minutes of each half will show a significantly higher injury potential than all other time periods.

1.4 Limitations

Possible limitations of the current study could arise through human/ operator error within the data collection stage. This is not uncommon in performance analysis due to the complexity of the soft wares used. Due to the unpopularity of spectatorship within women's soccer and the fact that all games will be gathered from online databases, a potential limitation could be the lack of access to a vast number of international soccer matches.

1.5 Delimitations

A delimitation of the present study could be that a study based on playing actions in Women's soccer has not previously be conducted therefore presenting is a distinct gap in research. This ensures that results found are original and could influence the way in which injuries are viewed within women's sport.

1.6 Definitions of terms

Throughout the current investigation several terms in relation to injury will be mentioned such as injury potential or risk of injury as well the degrees of injuries that occur; mild, moderate, high and actual. The majority of these terms will be defined in the methods section of the paper, however it should be stated that injury potential is classed as any action or time period that possesses some level of risk to injury to the participant. The term injury potential may often be referred to as IP.

CHAPTER II
LITERATURE REVIEW

2.0 Literature Review

2.1 History of Soccer

Soccer is viewed as one of the world's most popular organised sports with over 200 million males and 40 million females registered with FIFA as a player (Dvorak and Junge,2000, Giza et al., 2005, Tegnander et al., 2008,). Early evidence shows soccer being played as a sport started in China during the 2nd and 3rd centuries BC (History of soccer, online). A great deal of the increase in participation is through the prompt rise in the number of female players. The beginning of the 20th century saw US women's soccer gain high popularity and international acclaim even in countries where soccer does not have a renowned historical record of popularity such as China and India (Kirkendall et al., 2010, History of soccer, online). With the growing number of licensed female soccer players, the number of sport specific injuries has also increased (Biedert and Bachmann, 2005).

The infinite amount of participation in the sport and its vigorous nature provide an understanding of the high injury incidence compared with other sports: 17-24 injuries per 1000 playing hours (Rahnama et al.,2002). Dvorak and Junge (2000) have also stated that the frequency of soccer injuries is estimated to be approximately 10-35 per 1000 playing hours. As the outcome of any event within professional soccer matches is often reliant on chance, the best way to assess the overall levels of risk in any activity is to detect the fundamental causes and severity of these injuries that occur as well as and measuring their frequency of occurrence (Hawkins and Fuller, 1996; Hawkins and Fuller, 1998).

2.2 Injuries in soccer

The most common injuries in soccer consist of the lower extremities; ankle and knee joints as well as the ligaments of the thigh and calf comprising of 60-85% of the total number of injuries that are inflicted on soccer players of both genders (Fried and Lloyd, 1992, McGregor and Rae, 1995, Rahnama et al., 2002,). Fried and Lloyd (1992) discovered that injuries to external and internal structures of the knee joints including sprains of the hamstring and quads are relatively frequent and more disabling. This is supported by the results of Arnason et al (2005) who found that hamstring strains were the most frequent injury occurrence in Icelandic male soccer. Most of the injuries occurring in soccer seem to be muscle and ligament injuries with 37% of all time loss injuries at men's professional level soccer (McGregor and Rae,1995, Hagglund et al., 2012,). However in a study conducted by Roass and Nilsson (1979) results illustrated that the largest injury occurrence were leg fractures accounting for nearly 100 injuries in Norwegian soccer yearly. According to

Hagglund et al (2012) 90% of all muscle injuries within soccer involve the four major muscle groups of the lower extremity- adductors, hamstrings, quadriceps and calves.

There are several injury types that can occur within sport with the most common being overuse and traumatic injuries. The frequency of traumatic injuries differ greatly between sport with contact sports such as soccer, wrestling and rugby having higher rates of traumatic injuries. In contrast to this, overuse injuries are becoming increasingly common constituting of between 2 and 37% of all injuries within soccer (Ekstrand and Gillquist, 1983, Nielsen and Yde, 1989, Engstrom et al., 1991, Poulsen et al., 1991, Arnason et al., 1996, Luthje et al., 1996, Hawkins and Fuller, 1998).

2.3 Injuries in Female Soccer Players

It is stated that women are more prone to injury when participating in sporting activity having an injury rate 2.38 times higher than their male counterparts. (Roass and Nilsson, 1979, Giza et al., 2005, Bowerman et al., 2006). It has been proposed that both skilled and beginner female soccer players have an injury incidence rate of up to 31 injuries per 1000 competition and training hours (Giza et al., 2005). Faude et al (2005) completed a study on 165 German female soccer players in which it was found that 115 players experienced 241 injuries (70%) throughout the period of the study.

Women soccer players have also been recognized as having higher incidence in knee and ACL injuries than males; accounting for 49% of all injuries that arise in female soccer (Arendt and Dick, 1995, Engstrom et al., 1991, Giza et al., 2005, Bowerman et al., 2006). Murphy et al (2003) observed that in intercollegiate sports, female soccer players were 9 times more likely to withstand ACL tears than male players.

Differences to this have been shown throughout various studies that have analysed injury incidence in soccer competitions stating that males have a higher incidence of injury than their female counterparts (Junge and Dvorak, 2004). Giza et al. (2005) established that the injury incidence from the Women's United Soccer association is lower than the 6.2 injuries per 1000 hours in male's major league soccer. It was suggested however, that the majority of soccer injuries that occur are deemed to be minor and no more serious than injuries that take place in other sporting activities responding to exercise therapy and therapy modalities (Inklaar, 1994, Tucker,1997).

2.4 Causes of injury

It has been observed that injury risk within soccer seems to increase in a competitive situation compared to in training or practice; soccer players being at least 3 times more likely in competition (Rahnama et al.,2002, Murphy et al.,2003, Junge and Dvorak, 2004). McGregor and Rae (1995) found that 79% of injuries were sustained in competitive matches as well as Giza et al (2005) concluding that the occurrence of injury during practice was 1.17 per 1000 player hours in comparison to 12.63 for every competitive 1000 hours. Arnason et al (2005) stated that muscle strains were the most frequent injury type that occurred within matches (8.4 injuries per 1000 hours). The reason for this is deemed to be the increase in tackling and player-to-player contact during a competitive environment that pose more of an injury risk to soccer players, accounting for approximately 50% of all soccer injuries (Dvorak et al., 2000, Rahnama., 2011). Hawkins and Fuller (1996) and Rahnama et al (2002) found that 83% of all moderate injuries resulted from receiving a tackle as well as major injuries being attributed to receiving a tackle or contact with another player. In a 1998 study, Hawkins and Fuller also indicated that the main mechanisms leading to these player- to- player contact injuries were being tackled, heading the ball and making a tackle.

A number of previous studies have investigated the intrinsic factors associated with the occurrence of injury; these intrinsic factors include gender, age, skill level that may be influential (Dvorak et al., 2000, Murphy et al., 2003, Twellaar et al., 1997, Vanderlei et al, 2013). Arnason et al (1996) found that players aged between 29-38 had a higher risk of injury. The factors addressed by these studies, however, are internal characteristics of an individual and therefore a possible preventive programme would not be feasible as they are non-modifiable and adjustable (Bartlett and Bussy, 2012).

Fatigue is classed as a major reason for injury occurrence in soccer matches. This is defined as the decline in performance due to the necessity to continue performing affected by a reduction in energy (Carling et al., 2005). Hawkins and Fuller (1996) found that injuries were more common in the second half of matches, with heat stress being a possible contributory fatiguing factor effecting general failure to maintain muscle flexibility. Players tend to experience fatigue in the latter stages of the game due to decline in performance and decreased eccentric hamstring strength (Carling et al., 2005, Small *et al*., 2009). This decreased hamstring strength could explain the vast amount of hamstring injuries that occur especially during the final fifteen minutes of each half as well as causing an increased

predisposition of hamstring strain injuries (Small *et al.,* 2009). It is said though that fatigue can be offset by adapted fitness training, good nutritional habits and appropriate tactical decisions (Carling et al., 2005).

It has also been stated that previous injury has been associated with an increased risk of injury within soccer (Dick et al., 2007, Hagglund et al., 2006). It has been discovered that the more previous injuries a player had suffered, the greater the risk of injury (Dvorak et., 2000, Kucera et al., 2005, Hagglund et al., 2006). A study completed by Nielsen and Yde (1989) found that 42% of injured players had an injury of the same type and of the same location within a year. However according to Hagglund et al (2006) recurrent injuries account for some of the association between previous and increased injury risk in general but in some cases the injuries were viewed to be anatomically unrelated.

2.5 Analysis of injury risk movements

Previous studies have shown the development of effective prevention being hampered by the lack of sufficient detail on the incidence, causes, severity, outcome and cost of injuries (Campbell and Stone, 1996). Therefore, in order to maximise safe participation for the players and due to the increase of injuries; sports trainers, physicians, physical therapists, team medical staff and coaches need to have a basic understanding of common injuries and problems as well as being aware of appropriate prevention programmes (Tucker, 1997, McMaster and Walter, 1978, Rahnama, 2011).

Given the popularity and the growth in performance analysis over the last decade, it is now deemed important for professional clubs to employ individuals to directly provide performance analysis as it is seen as an integral part of the coaching process (Mackenzie and Cushion, 2013). Video footage of players performing technical skills such as passing, shooting and heading for example, can be used to evaluate technique, provide feedback and help design relevant practice sessions as well as using computerised analysis in the assessment of injury in matches (Carling et al, 2005).

For the purpose of this study, notational analysis was carried to determine the injury potential of a playing action. Injury potential was assessed by the injury incidence rate; defined in terms of the number of injuries and exposure to injury usually in accordance with time. Notational analysis is a method of recording and analysing dynamic and complex situations, such as field games allowing data to be gathered in an efficient and abstract way that focuses on relevant detail (Hughes and Franks, 2008). Hughes (1998) proposed five

purposes on notational analysis; tactical evaluation, technical evaluation, analysis of movement, coach and player education and performance modelling using match analysis databases.

Both technical evaluation as well analysis of movement are deemed important when analysing a playing actions injury risk. Injury severity is usually classified as minor, moderate, or major depending on the length of time needed for recovery, with over 65% being minor, 25% moderate, and 10% serious or major (Rahnama et al, 2002). In field sports such as soccer, movement activities are generally coded according to their intensity which is usually determined by the speed of the action or when evaluating performance, the frequency of each type of movement or the distance run in each movement can be analysed (Carling et al., 2008). In relation to this, potential injury risk of an action within several studies have often been determined by the vigour, context and nature of the action performed (Rahnama et al., 2002).

Rahnama et al (2002) conducted a study that assessed the exposure of players to injury risk during English Premier League soccer matches in relation to a number of factors that may influence the risk. 7667 actions were deemed to have possessed some level of injury potential, 20 of these actions resulting in actual injuries, which is an average of two per game. The study involved analysing male soccer players however due to the vast amount of information suggesting that women players are more susceptible to injury in soccer. The aim of the current investigation is to assess injury risk of women soccer players in relation to playing actions and a number of other aspects that may involve risks. With the increasing number of female soccer players and the scarce amount of research on the topic the current investigation is deemed to be important.

CHAPTER III
METHODS

3.0 Methods

The following section will outline the methods employed in the selection and analysis of the relevant performances.

3.1 Sample/ collection of footage.

Sixteen women's soccer matches were analysed for the purpose of this study. All matches were played at the London 2012 Olympic Games and therefore all participants were at an international standard. These matches were chosen for analysis as they were the only matches available at easy access.

Table 1. List of Matches coded throughout the analysis process.

	MATCHES
1	USA vs France
2	Sweden vs South Africa
3	Cameroon vs Brazil
4	Great Britain vs Cameroon
5	Columbia vs Korea
6	Great Britain vs New Zealand
7	Great Britain vs Brazil
8	Canada vs France
9	USA vs Japan
10	Canada vs USA
11	USA vs Korea
12	USA vs Columbia
13	Japan vs Sweden
14	Canada vs Sweden
15	Japan vs South Africa
16	France vs Japan

3.2 Video footage

Matches were cited from a public domain website; YouTube®, as well as from the Cardiff Metropolitan University database. Due to the availability of the videos through the public

domain, no independent recordings were filmed and no informed consent was required to carry out the analysis process. The study focuses on the playing actions alone and not the participants completing those actions as a result no specific group of participants were analysed at one time and teams differed from game to game ensuring that all data collected can be generalised due to the variability of the participants.

3.3 Equipment

Time-motion analysis was performed from a series of video recordings of female soccer matches. Video footage was downloaded onto a 21" Apple iMac for data collection and imported into the system for analysis post event. Actions were coded through a computerised system; Studio code, v5 (Sportstec, Australia) in which a particular code window was created for the purpose of analysis. Studio code is a general match analysis package in which the system is defined using a Code window containing two button types; event buttons and labels (O'Donoghue, 2015).

3.4 Pilot study.

A pilot study was completed before analysis process began. It is said that a pilot study has numerous purposes such as developing, testing the capability of research instruments and assessing the feasibility of the full study (Connelly, 2008, Jairath et al., 2002). Whilst conducting the pilot study, it was decided to remove one of the action variables; receiving the ball, due to the high speed of the playing actions within a game and the inability to carry out accurate analysis when this playing action was involved. It was also discovered that in order to create precise results, when more than one of the same action was performed after each other, it is required for the code button to be clicked off and then on again ensuring all playing actions are coded correctly.

3.5 Instrumentation

In order to objectively collect data relating to performance, a specific code input window was designed in the Studio code, v5 (Sportstec, Australia) software package. Playing actions were analysed in relation to thirteen different soccer specific actions to identify what playing actions possess the highest risk of injury throughout a match.

Event and label buttons were created within the code window in which event buttons included all action variables and label buttons; each injury potential category. This allowed for each playing action to have an individual injury potential. Each event button was

exclusively linked meaning that each button would automatically turn off when a new action was coded.

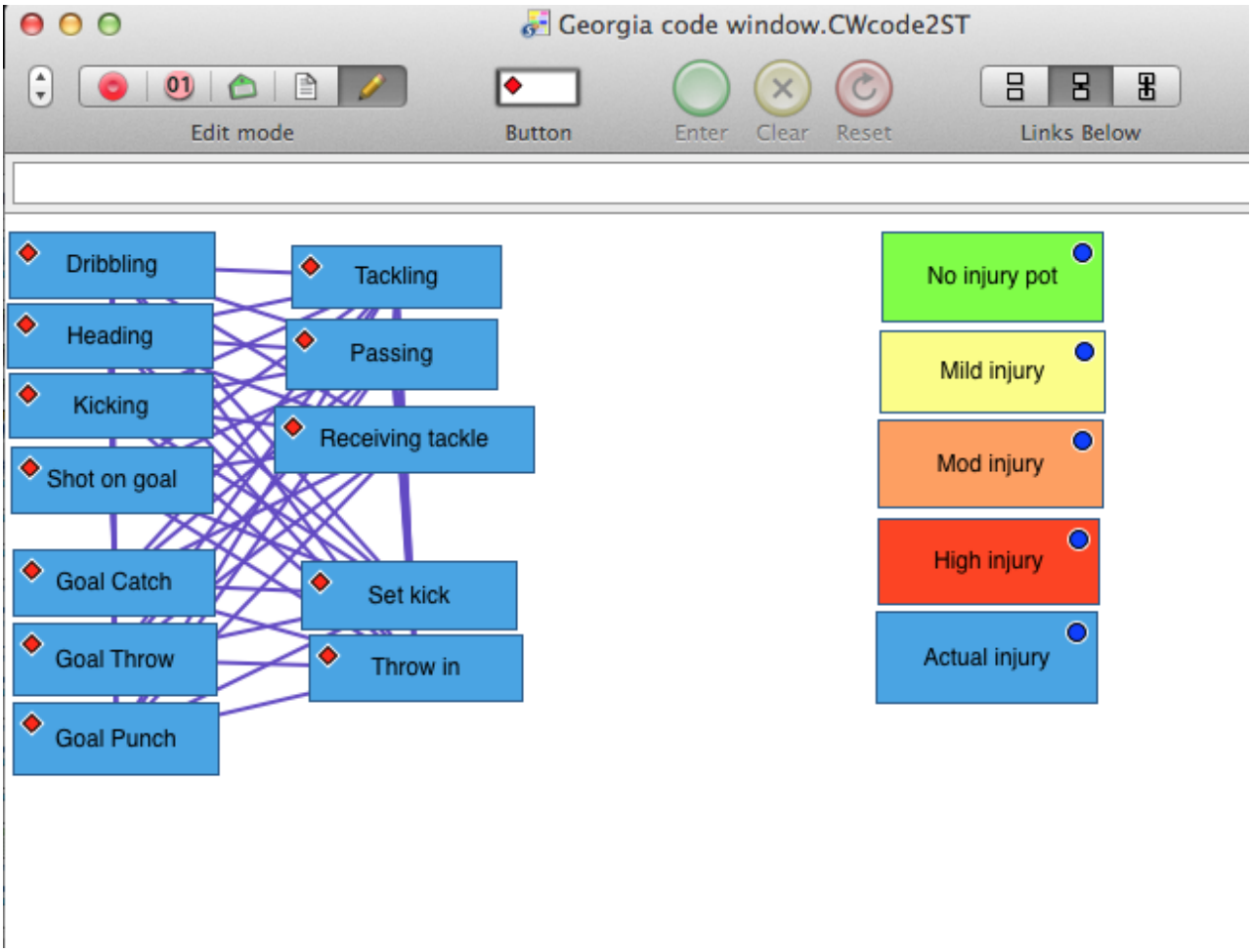

Figure 1. Shows an example of the code window used for the basis of analysis.

3.6 Operational definitions.

It is essential within performance analysis that all performance indicators have clear operational definitions. Therefore action variables should be defined with a level of precision making their meaning unambiguous (O'Donoghue, 2007).

The following operational definitions of playing actions are cited from Rahnama et al (2002):

Table 2. List of all the operational definitions for each action variable.

PLAYING ACTIONS	OPERATIONAL DEFINITIONS
DRIBBLING THE BALL	With close control to take the ball past an opponent using the foot with 3 or more touches
GOAL CATCH	Goal keeper catches and holds onto the ball
GOAL PUNCH	Goal keeper punches the ball and doesn't keep possession
GOAL THROW	Goal keep distributes the ball by throwing towards a team mate.
HEADING THE BALL	Player makes direct contact with the ball using their head.
KICKING THE BALL	Player makes direct contact with the ball with the foot
MAKING A TACKLE	Player actively moves their body or limbs towards the ball when the ball is in possession of an opponent
RECEIVING A TACKLE	Player in possession receives a tackle by opponent
PASSING THE BALL	Player plays the ball with the foot with the intention of a team mate receiving it.
SHOT ON GOAL	Any attempt made by an attacking player with a shot/kick directly towards the goal.
SET KICK	A free kick situation anywhere on the pitch (including a corner).
THROW IN	Restart of the game with the hands following the ball going outside the touchline.

These playing actions were analysed in relation to 3 categories depending on the likelihood of injury; no injury potential, injury potential and actual injury. Actual injury was defined as receiving medical treatment leading to absence of the pitch whilst the no injury potential category was used where there was no apparent possibility of injury occurrence. Injury potential was then separated into 3 subcategories identified as mild, moderate and high.

Mild actions were coded when a small likelihood of injury was possible such as kicking the ball unchallenged. An example of a moderate action would be heading the ball with close contact to opposition and a high injury risk action would consist of receiving or making a vigorous tackle. It should be mentioned however that all actions have the potential to possess any injury potential category depending on the context at which it is performed. These variables were implemented into the code window as text labels for the basis of analysis.

For the process of analysis the duration of the match was split into 6 individual 15 minute periods. Therefore, whilst analysing the data, after each period of play the data collected during that period was exported from the software to allow for time based data to be gathered and compared. This enabled identification of the injury potential throughout the several periods of play to observe which period possessed the highest level of injury risk.

3.7 Procedure

Match footage of a single game was imported into the Studio code V5 (Sportstec, Australia) system for analysis. Each half of the game comprised of analysis of one team only therefore analysis was conducted on each team for a 45 minute period. The code template was activated and the order of the information coded remained the same throughout the process:

1. Movement type
2. Injury potential

After each action occurred the movement type and its potential injury risk was coded into the software gathering a series of data of each action and its individual injury potential.

All of the recorded information was displayed in a timeline and after the analysis, was viewed in a statistical matrix. Once all instances had been checked in the timeline, data was exported and transferred to a Microsoft Excel spreadsheet for analysis. This process was repeated for each match.

3.8 Statistical analysis

Data relating to the playing action, injury potential and time elapsed in the game was imported into Microsoft Excel. This enabled the descriptive analysis of frequencies of events during the six 15 minute periods to be defined. The data relating to each game was processed in Microsoft Excel to calculate the injury potential for each playing action; the sum of actions with some level of injury risk as well all actual injuries that occurred in each playing action. This was then divided by the total number of actions made in that category/action

and expressed as a percentage. Similar analysis was completed on time period data in which mild, moderate, high and actual injury potential actions were added, divided by the total actions in that period and expressed as a percentage. As well as an overall injury potential percentage for each action and time period, mild, moderate, high and actual injury potential percentage were calculated in a similar manner. Unlike the study of Rahnama, Lees and Reilly (2008) it was decided that genuine risk of injury would be quantified by the sum of mild, moderate and high injury potential.

Statistical testing was carried out on SPSS Statistics Data Editor to identify any significant differences between playing action and time period data. A Friedman ANOVA test was completed to test for differences between the groups. If this value was less than 0.05; showing results to be significantly different a Mann-Whitney U Test was then completed testing each individual variable against each other. By testing each group against each other, identification on significantly differences are gathered, allowing for a more precise and accurate outcome of results. Both tests are an example of non-parametric tests comparing sets of data against each other.

3.9 Reliability

Within a performance analysis study, reliability of measurement is said to be a common and essential feature so that information produced can be interpreted with a full understanding of the measurement error involved (Bartlett, 2000, O'Donoghue, 2007). Therefore, in order to gain information on the reliability of the analysis process within the present study, an intra-operator reliability test was carried out. According to O'Donoghue (2007) an intra-operator reliability study involves an operator analysing a performance on two or more occasions using the given performance analysis system. For the present study, a 20 minute period of the same soccer match was analysed. Reliability analysis occurred half way through the analysis process and each 20 minute period was analysed a week apart. This allowed for accurate and true reliability values to be observed as the operator was neither a novice at using the specific software nor were they too comfortable in the process. Kappa values of 0.6 and 0.69 were calculated for the movement types and injury risk data as well as 0.94 for time based reliability (See Appendix B). Therefore it could be said that this study has moderate/ high levels of intra-operator reliability. It should be stated however, that due to the nature of the analysis it is possible to accept moderate reliability values as defining movements is often deemed to be intricate and difficult.

CHAPTER IV
RESULTS

4.0 Results

4.1 Overall Findings

A total number of 8535 actions were recorded throughout the 16 games observed with 3650 actions possessing some level of injury risk. 17 of those actions resulted in actual injuries (an average of 1.1 per game). Figures 1 and 2 show the total number and overall percentage injury potential within each category used displaying an overall injury potential of 43.1 per 24 hours played.

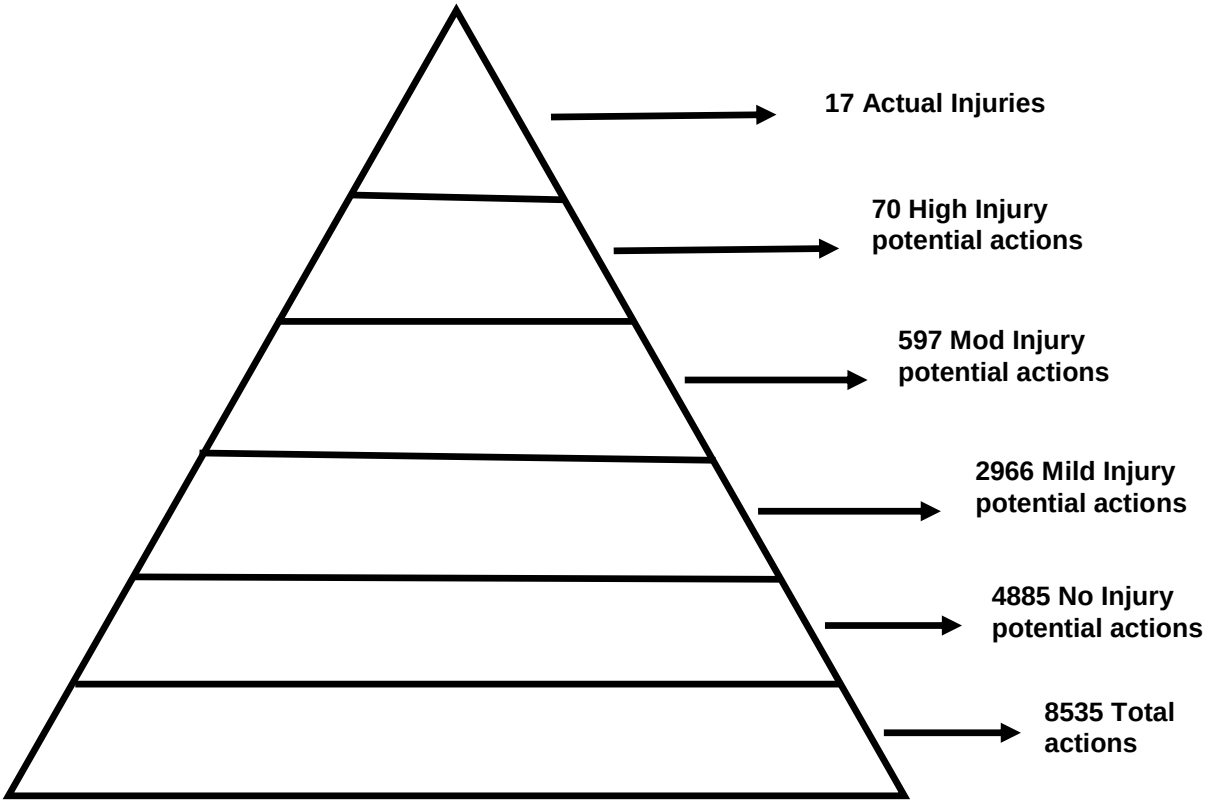

Figure 2. Shows the total number of actions, the actions within each injury potential category and the actual injuries observed.

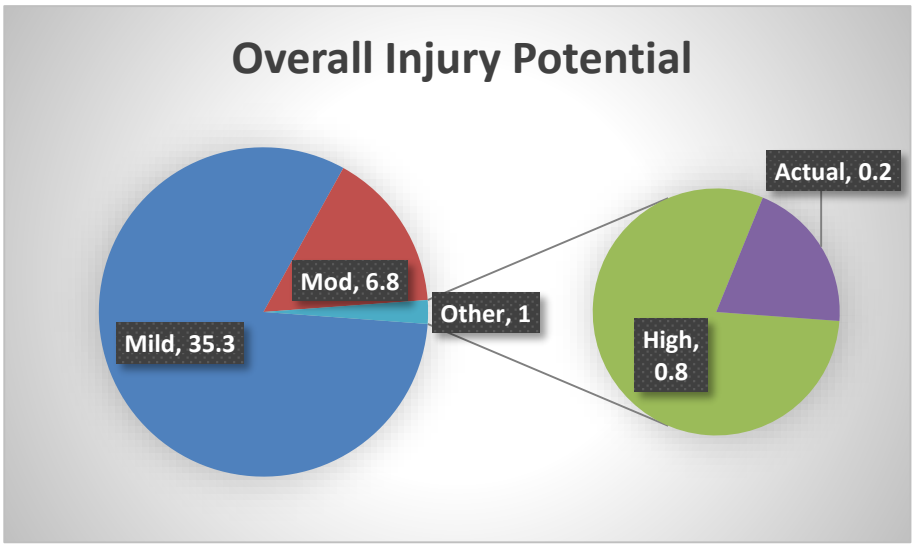

Figure 3. Overall injury potential for each category (expressed as a percentage).

4.2 Playing actions

Results show that tackling and receiving a tackle possess the greatest injury risk revealing a 97% and 98% injury potential (See Figure 3). The majority of injuries arose from a tackle accounting for 6 of the total 17 (35.3% of all injuries), receiving a tackle (23.5%) heading (17.6%) and kicking (11.8%).No injuries occurred from performing the following actions; Passing, dribbling, goal catch, goal throw, goal punch and set kick (See Table 3).

Figure 4. Shows overall injury potential for each playing action (expressed as a percentage).

Table 3. The total number of injury potential actions within each category for each playing action.

Playing Actions	***No Injury Potential***	***Mild***	***Mod***	***High***	***Actual*** *
Kicking	753	469	20	1*	2
Heading	130	506	57”	11”	3
Passing	3220	497	7”*	0	0*
Tackling	21	633”*-	239”*-	21”-	6-
Receiving a tackle	10	430+	234”*-	36”-	4
Dribbling	114	285”*-+#	21*+#	1*+#	0*+
Goal Catch	47	47	6	0	0
Goal Throw	20	7	0	0	0
Goal Punch	3	20	6	0	0
Set Kick	209	1”*-+#/(	0”*-+#/	0”*-+#/	0
Throw in	299	6”*-+#/(	0”*-+#/	0”*-+#/	1
Shot on goal	59	65”*-+#/	7”*-+#/	0”*-+#/	1

indicates significant differences from a head (p= <0.05)

- indicates significant values from a pass

+ indicates significant differences with a tackle

“ indicates significant differences with a kick

# indicates significant differences from receiving a tackle

/ indicates significant differences from a dribble

) indicates significant differences from a shot on goal

Table 3 presents the injury potential actions for each playing act. Each playing action displays an overall injury risk as well as an injury risk percentage for each category (See Appendix A). Kicking (60.5%), Passing (86.5%) Goal Throw (74.1%), Set Kick (99.5%) and Throw in (97.7%) were classed as having mainly no injury potential due to their highest percentage of actions being in that category. All other actions were classed as mild injury risk category however it should be stated that receiving a tackle (32.8%), tackling (26%) and goal punch (20.7%) possess a reasonable percentage in the moderate injury potential category.

Significant differences tests were completed through two individual tests; Friedman ANOVA and Mann Whitney U Test. For the purpose of the statistical testing specific goal keeper actions was removed and an individual test was carried out on goal keeping actions alone. All Friedman test results show significant values (p=<0.05) of .000 apart from that of actual injury potential in which the value of 0.10 and goal moderate injury potential; 0.32. Goal high and actual injury potential did not possess a high enough value for significant results to be observed. Significant difference values of playing action data are shown in Table 3.

4.3 Time periods

Each 15 minute period and its injury potential is presented in figure 5. From the graph it is possible to observe that the number of actions is predominantly greater in the first 2 periods of the game than the last 4. Having said this, it should be stated that the overall injury potential for the last 4 periods of the game is greater; 3rd 15 (44.6%) 4th 15 (43.9%) 5th 15 (43%) and final 15 (46.5%) showing a larger injury risk in the second half of play. Actual injury occurrence is in accordance with this, with an overall of 15 injuries occurring in comparison to only 2 injuries in the first 45 minutes of play.

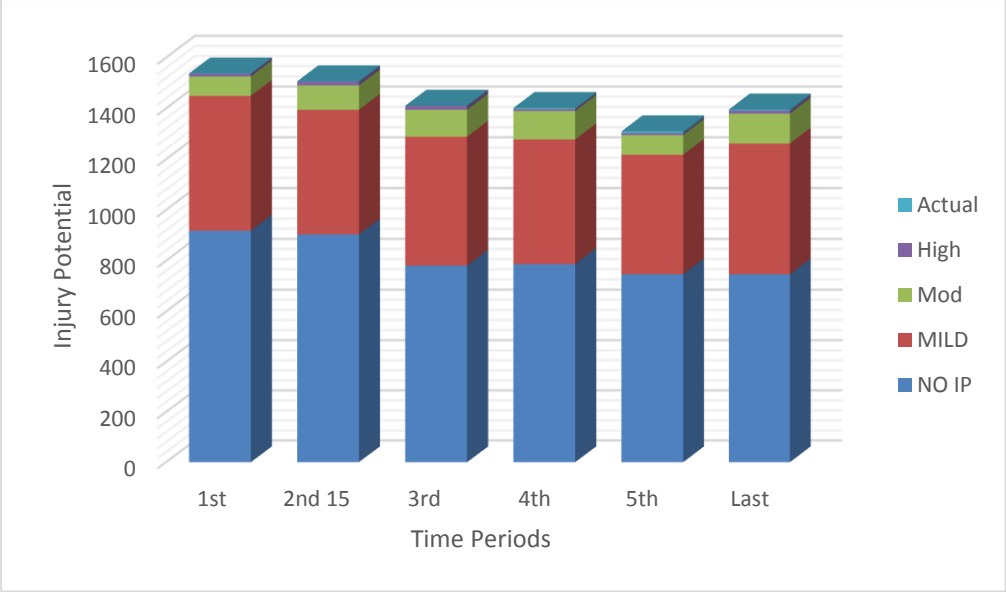

Figure 5. Potential injury risk for each category within the six 15 minute periods of the games.

Table 4. The number of actions and their injury potential for each period and the overall injury potential expressed as a percentage.

	No IP	*Mild*	*Mod*	*High*	*Actual*	*Injury Potential*
1st	919	531	76-	11-+	1-+	40.2
2nd 15	904	491	96-*	15-+	1-+/	40.0
3rd	781	508	106-^	16-+	0-+/	44.6
4th	787	491	112-^	8-+	4-+	43.9
5th	747	471*$	77-^	8-+	7-+	43.0
Last	747	515	118-^£	12-+	4-+	46.5

- indicates significant differences with mild actions (p=<0.05)

+ indicates significant differences with moderate actions

/ indicates significant differences with high actions

* indicates significant differences between the first 15 minutes of play

^ indicates significant differences between the 2nd fifteen

$ indicates significant differences between the 3rd period of play

£ indicates significant differences between the 5th 15 minutes

It is shown in Table 4 that the highest actual injury period is the 5th 15 minutes of the games in which 7 injuries occur, followed by periods 4 and 6 with 4 injuries each. However, the 3rd period has been shown to possess a higher injury percentage in relation to period 4 and 5. As with the playing action data, two individual statistical tests were completed for the purpose of this study. After completing the Friedman ANOVA test results showed significant values between all mild and moderate injury potential actions as well as within each period of play however high and actual injury potential actions show no significant differences; 0.436 and 0.628. Significant differences within time periods and within injury potential categories are shown in Table 4.

CHAPTER V
DISCUSSION

5.0 Discussion

The aim of the current investigation was to assess the exposure to injury risk within women's international soccer matches by analysing playing action and time period data. Assessment of critical incidents that possess injury potential as well as actual injuries in relation to these aspects of the game were identified. The overall injuries that occurred during 16 games (24 hours) was 17; accounting for 1.1 injuries per game and an overall injury percentage of 43.1%. This shows a higher injury incidence rate than previous studies (Dvorak and Junge 2000, Arnason *et al.,* 1996, Inklaar, 1994) as well a higher incidence of injury in relation to other sports (Engstrom *et al.,* 1991, Hawkins and Fuller, 1998, Rahnama, 2011). It should be noted however that this injury incidence rate represented actions around the ball and not actions such as running and other off the ball movements. Therefore, conclusions on injury risk/ potential within soccer can only be drawn from this study when referring to playing action injuries and not that of locomotive actions.

5.1 Playing actions.

The present study found that actions with the highest injury potential involved player-to-player contact such as making and receiving a tackle attributing to 10 of the 17 (58.82%) injuries that arose. It is believed that when the rules of the game allow significant contact, athletes are at high risk of player-to-player contact injuries; 55%-78% injuries within wrestling and football were deemed to be caused by player-player contact (Kerr et al., 2011). The findings from this study are in agreement with the results of several researchers (Dvorak et al., 2000, Rahnama, 2011, Hawkins and Fuller, 1996, Rahnama et al., 2002) in which it is stated that approximately 50% of all injuries that occur are due to player-player contact such as collisions, tackles and receiving a tackle. It has also been proposed that the increase in injury occurrence during competition in comparison to training is deemed to be through player-to-player contact and the increase in tackling (Dvorak et al., 2000). Hawkins and Fuller (1996) stated that the majority of moderate injuries that occurred resulted from receiving a tackle. Many researchers provide reasoning for the large proportion of player-to-player contact injuries that occur within soccer offering explanations such as unfair and illegal play and insufficient warm up periods making the body less agile and more susceptible to injury (Dick et al., 2007, Robinson et al., 2011).

Results from the current study indicate that not only heading (17.6% of all injuries) but also kicking the ball (11.8%) are contributory factors to the overall injuries resulting in 5 injuries between these movement types. Hawkins and Fuller (1996) found that heading the ball was one of the main mechanisms leading to injury. It has also been said that injuries can result from kicks, direct contact from a kicked ball or contact with the playing surface during a fall (McMaster et al., 1978, Dick et al., 2007).

Results from the present study show that one injury occurred from a throw- in. This action compared with actions such as passing, kicking, heading and tackling do not arise as often making the chance of injury incidence reasonably low; (Throw in: 2.3%). This result supports the assumption that all actions possess some level of potential to cause injury within soccer. The action shot on goal from the results is shown to be a cause of 1 of the 17 injuries that occurred. Even though this action is similar to that of a throw in, in that it is not performed as frequently as other actions, injury potential is shown by reasonably high; 55.3% and therefore the resulting injury that occurred from the action is not surprising. However, it is assumed that there is no reference to this specific action being a major contributory factor in injury incidence within soccer throughout the vast amount of literature on the subject.

It should be noted however, that even though injuries occurred from these actions, several playing actions did possess higher injury potential percentages due to their larger sum of mild, mod, high and actual injury potential actions; goal punch (89.7%), dribbling (72.9%), goal catch (53%). Rahnama et al (2002) agree that these actions possess a significant level of injury risk however findings from their study also found a set kick to possess substantial levels of injury potential. These actions have been generally ignored throughout the literature until the works of Rahnama et al (2002) seeing the importance of these actions due to their possible influence in injuries triggering continuous occurrence of injury in soccer.

The findings of this study allow players to protect themselves from injury by avoiding or limiting actions that possess high injury risk as well helping coaches to adapt training sessions so that the risk of injury is as low as possible. (Rahnama et al., 2002). In order to decrease this risk coaches can develop conditioning sessions for players based on several actions that are deemed to be major causes of injury. It should be mentioned however, that due to the competitive and vigorous nature of the sport it is possible that every action has some element of risk and has the potential to cause an injury depending on the context at which it’s performed.

5.2 Time periods.

For the purpose the current investigation periods of the game were split into six fifteen minute time periods in order to establish differences between each period in relation to injury potential. It was discovered that the last 15 minutes of each half possessed the highest percentage of injury potential however, the second half of play abstained a significantly greater level of injury risk in comparison to that of the first half. It is said that at the end of each half and following the half time interval performance is impaired due to fatigue as well as the period of inactivity during half time (Alenton-Geli et al., 2009). These results differ from the findings of Rahnama et al (2002) and Ekstrand and Gillquist (2008) who reported that most occurrence of injury was in the first 15 minutes of each half. They suggested that performers were susceptible to injury in the first period of each half due to insufficient warm up or the assumption that the first 15 minutes are the periods in which performers put the greatest effort into.

Similar results to the current study however, were found in several studies (Hawkins and Fuller, 1996, Arnason et al., 1996) discovering that the risk of injury was at its highest in the second half of play. The results of the present study differ to various literature in that most injuries occur in the final 30 minutes of the second half, as opposed the majority of research stating that most injuries occur in the final 15 minutes of each half. In contrast to this, Dick et al (2007) stated that the risk of injury is considered to be at its highest in the first and last 15 minutes of play where players are fighting for possession of the ball under increased pressure. This could be a reasoning behind the cause of injury within the final period of play within the present study.

Several researchers class fatigue as a major reason for injury occurrence within soccer, causing decreased muscle strength, hypo hydration and depletion of glycogen stores (Hawkins and Fuller, 1996, Rahnama et al., 2002, Carling et al., 2005, Small et al., 2009). Hawkins and Fuller (1996) proclaimed that fatigue and heat stress is stated as a possible cause of injury occurrence by negatively altering the biomechanics of running in relation to muscle flexibility, strength or body mechanics (Small et al., 2009). According to Rahnama et al (2002) this causes increased exposure to injury or damage that has been incurred in

the game to become more evident as play is sustained, due to an athlete's inability to perform on an injury for a long period of time. Robinson et al (2011) also stated that match related fatigue has a greater influence on a player's ability to get involved with the ball. This is relevant to the present study and could be a possible reasoning behind injuries occurring when completing actions with the ball.

Findings from the present study however, show a larger number of high injury potential actions in the first half of play with only 2 injuries occurring. However in contrast this, the second half of play, even though showing lower high and moderate injury potential levels possesses a higher number of injury occurrence with a total of 15 injuries in the second half alone. This is in contrast to the results of Rahnama et al (2002) finding that the opening 15 minutes of play possessed the most actions with mild injury potential with the closing 15 having the most moderate injury potential actions. Rahnama et al (2002) found within their study, that more injuries occurred in the first 15 minutes of play, with the current study finding most injuries in the final period of the game. Therefore, it could be assumed that most injuries occur when mild injury potential is at its highest. Rahnama et al (2002) stated that an injury may occur simply because of the number of events increasing the chance of one of them becoming an injury. Hence it could be stated that the larger numbers of mild injury potential actions, when repetitively carried out increase the likelihood of injury occurrence.

5.3 Injury potential in female soccer

This study investigated women's international soccer matches in order to observe whether female participants possess a higher risk of injury than their male counterparts as observed in the study by Rahnama et al (2002). Previous research has suggested that women soccer players have a 2.38 higher injury rate than males (Roass and Nilsson, 1979, Giza et al., 2005, Bowerman et al., 2006). Sallis et al (1996) state that female have a higher rate of injury to the shoulder, lower leg and hip. A number of researchers have declared that female basketball and soccer players sustain more injuries overall, more injuries to the knee and more injuries than male players (Powell and Barber-Foss, 2000, Rechel et al., 2010).

Giza et al (2006) affirmed that both professional and amateur female soccer players have an incidence of up to 31 injuries per 1000 game and practice hours. In relation to this, a study was conducted on 165 female soccer players assessing their injuries throughout a period of time; 115 (70%) of these players experienced an overall of 241 injuries therefore

suggesting that once a player had acquired an injury they were more susceptible to injuries reoccurring. Previous injury has also been associated with the increased injury risk within soccer (Dick et al., 2007). Nielsen and Yde (1989) conducted a study in which they looked at injured players. In the year prior to the study, the 42% of the injured players acquired an injury of the same type and at the same location. Within this study it was observed when analysing that several players did have strapping or taping to indicate previous injury or present recovering from injury however, due to the nature and aims of the study, specific information on this was not noted.

According to Murphy et al (2003) female soccer players were also 9 times more likely to sustain an ACL tear injury .It has also been stated that female athletes have a higher percentage of overuse injuries compared with traumatic injuries showing opposite injuries for male players (Stracciolini et al., 2014). This could be an explanation as to why injuries occurred where mild injury potential was at its highest as the performer may have not fully recovered from a previous injury such as an ACL tear.

In contrast to this, the results from Giza et al (2005) show that women's soccer has a lower injury incidence in relation to 6.2 injuries per 1000 hours in male soccer as well as Junge and Dvorak (2004) concluding a higher incidence in men than women in soccer tournaments. This is backed up the study by Rahnama et al (2002) showing a higher injury incidence rate; 20 injuries throughout 10 games (2 per game) than the present study; 17 injuries in 16 games (1.1 per game). In order to specifically compare gender differences the study would need to analyse both male and female soccer games to gain accurate results.

5.4 Implications

5.4.1 Practical Implications

Prevention programmes are often implemented in sport but it has been noticed that injury prevention programmes need to be developed to increase the effectiveness and decrease the risk of injuries occurring within soccer. McMaster et al (1978) stated that injury prevention in soccer requires an adequate and competent coaching staff that will embrace sound conditioning and training techniques. From the results of the present study it is difficult to produce a prevention programmes to reduce injury potential with regards to playing actions involving player-to-player contact that were deemed to cause injury as these actions cannot be controlled within a game situation. It is possible however, that these injuries were caused

due to actions of foul or unfair play in which case proper enforcement of the rules by officials is likely to decrease the risk of injury (Dick et al., 2007). Another way to decrease foul play actions from occurring is to show performers how to correctly perform the skill and ensure they understand what a foul play action looks like.

In relation to the time period data it is possible to create a prevention programme based on the assumption that performers experience injury when fatigued. According to Carling et al (2005) fatigue can be offset by specific fitness training, good nutritional habits and appropriate tactical decisions. Therefore, this programme could be designed to improve the fitness of the performer to ensure they don't fatigue as easily throughout the game. Heidt et al (2000) and Junge et al (2002) planned similar prevention programmes for male and female participants to increase the fitness levels of the players to decrease the fatigue effects during a game. They found the players that completed the prevention program acquired a lower incidence of injury compared to the untrained athletes with the male participants having a larger effect (21% lower injury incidence).

A prevention programme could also be based on the unsufficient warm up causing injury in which case correct warm up sessions would be given between both halves of the game to ensure players were appropriately warmed up and ready to perform.
It is said that an effective prevention program can allow for sound advice to be given to medical staff, coaches and referees to help them make a safer environment for the players and therefore decrease the risk of injury occurrence (Rahnama, 2011, Rahnama et al., 2002, Tucker 1997, McMaster and Walter., 1978). Producing prevention programmes to possibly decrease the injury incidence rate is stated as an urgent requirement to help reduce medical costs to the government from injuries within soccer (Dvorak and Junge, 2000, Schniff et al., 2010).

5.4.2 Strengths

As this study has not been completed within female soccer players previously there are several strengths to the current study regarding the information found. Results from this study show differences between Rahnama et al (2007) study conducted on male participants showing large differences in the periods of play that possess the greatest risk of injury. The findings obtained in this study suggest that mild injury potential actions can possibly be a substantial cause of injury within soccer presenting a new view for further investigation on

injury risk. This study also allows for possible prevention programmes to be developed to decrease the number of injuries that occur within women's soccer. From the results it is possible to observe that the findings show coherence with vast amount of research completed in the field of injury within sport.

5.4.3 Limitations

There are however a number of limitations of the current study due to the nature of the investigation. Human error within the data collection stage is present. When carrying out quantitative research human operators often follow objective measurement procedures so that data is independent of the particular operators involved, however, due to pressure the operator may not be able to fully apply the criteria set (O'Donoghue, 2010). Results from the present investigation is also shown to be relevant only when referring to playing action injuries and not to injuries within soccer as a whole. This due to the lack of locomotive movements analysed throughout the period of analysis. The present study does not provide information on what injuries as well as traumatology of those injuries that occurred from the movements. Therefore conclusions based on whether injuries were mostly traumatic or overuse and in what part of the body they occurred cannot be drawn. In order to further develop this study information on this would be advantageous to achieve a more detailed and useful set of results. Another way in which to improve the present study would be to interview and analyse the players at the start of the competition to identify any injuries that were currently present and therefore may have played a role in the injuries the occurred throughout the competition.

CHAPTER VI
CONCLUSION

6.0 Conclusion

The aim of the current study was to assess the playing actions in women's soccer to determine the injury risk/potential. The investigation achieved numerous aspects of its hypotheses in that player-to-player contact action possessed the greatest injury risk resulting in the majority of injury occurrence. The study also presented results differing to the current literature in that injuries resulted from both a 'throw in' and a 'shot on goal'. This backs up the statement that all actions within soccer possess some level of injury risk due to the vigorous nature of the sport.

Another aspect in which the hypotheses of the present investigation was met is that the last 15 minute periods of each half possessed the highest level of injury risk. However, it was found that the second half acquired a significantly greater risk than that of the first half with the most injuries occurring in the 5^{th} period of play. This research is in agreement with the works of Rahmana et al (2002) in that player-to-player contact is the major contributor of injury within soccer however disagrees with the time period data results; finding that the first 15 minute period of each half is the period in which the greatest injury risk is attained.

The results of the present investigation provide new information on injury risk within women's soccer. It also presents a rationale for future research on injury in women's soccer based on the type and severity of injuries that occur. It should however be stated that conclusions on injury risk in women's soccer can only be drawn from the current study when referring to actions that involve the ball and not locomotive movements.

CHAPTER VII
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APPENDICES

Appendix A

Playing Action	NO INJURY	MILD	MOD	HIGH	ACTUAL	No of injury pot	Total no of actions
Kicking	753	469	20	1	2	492	1245
Heading	130	506	57	11	3	577	707
Passing	3220	497	7	0	0	504	3724
Tackling	21	633	239	21	6	899	920
Receiving a tackle	10	430	234	36	4	704	714
Dribbling	114	285	21	1	0	307	421
Goal Catch	47	47	6	0	0	53	100
Goal Throw	20	7	0	0	0	7	27
Goal Punch	3	20	6	0	0	26	29
Set Kick	209	1	0	0	0	1	210
Throw in	299	6	0	0	1	7	306
Shot on goal	59	65	7	0	1	73	132

Playing Action	IP	IP percentage	No IP	Mild IP	Mod IP	High IP	Actual Injuries
Kicking	0.40	39.52	60.5	37.7	1.6	0.1	11.8
Heading	0.82	81.61	18.4	71.6	8.1	1.6	17.6
Passing	0.14	13.53	86.5	13.3	0.2	0.0	
Tackling	0.98	97.72	2.3	68.8	26.0	2.3	35.3
Receiving a tackle	0.99	98.60	1.4	60.2	32.8	5.0	23.5
Dribbling	0.73	72.92	27.1	67.7	5.0	0.2	
Goal Catch	0.53	53.00	47.0	47.0	6.0	0	
Goal Throw	0.26	25.93	74.1	25.9	0.0	0	
Goal Punch	0.90	89.66	10.3	69.0	20.7	0	
Set Kick	0.00	0.48	99.5	0.5	0.0	0	
Throw in	0.02	2.29	97.7	2.0	0.0	0	
Shot on goal	0.55	55.30	44.7	49.2	5.3	0	

	NO IP	MILD	Mod	High	Actual	IP	Total
1st	919	531	76	11	1	619	1538
2nd 15	904	491	96	15	1	603	1507
3rd	781	508	106	16	0	630	1411
4th	787	491	112	8	4	615	1402
5th	747	471	77	8	7	563	1310
Last	747	515	118	12	4	649	1396

Actions IP	IP	Percentages
No IP	0.569	56.9
Mild	0.353	35.3
Mod	0.068	6.8
High	0.008	0.8
Actual	0.002	0.2

Period IP	Percentages
0.40	40.2
0.40	40.0
0.45	44.6
0.44	43.9
0.43	43.0
0.46	46.5

Appendix B

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.603	.051	14.484	.000
N of Valid Cases		131			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.699	.058	9.846	.000
N of Valid Cases		135			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Behaviour	Time Agreed (SC)	Total Time Obs 1 (SC)	Total Time Obs 2 (SC)
passing	00:05:55.66	00:06:25.81	00:06:02.80
tackling	00:04:04.58	00:04:11.50	00:04:12.48
rec tackle	00:01:24.42	00:01:25.79	00:01:25.15
dribbling	00:00:40.42	00:00:47.49	00:00:47.46
set kick	00:00:46.44	00:00:47.45	00:00:52.81
heading	00:01:43.82	00:01:48.90	00:01:48.59
kicking	00:02:53.36	00:03:00.17	00:03:11.33
goal catch	00:00:51.49	00:00:51.49	00:00:51.49
shot on goal	00:00:41.83	00:00:41.83	00:00:44.86
Total			

P0	0.951940032
PC	0.185193974

Kappa = 0.94