Injuries in Adolescents and Coaches' Attitude towards Injury Prevention in Ladies Gaelic Football

Thesis submitted for the degree of Master by Research

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Abstract

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Title: Injuries in Adolescents and Coaches' Attitude towards Injury Prevention in Ladies Gaelic Football

Background: Sports participation has an inherent risk of injury, however, this injury risk does not outweigh the physiological, psychological and social benefits observed with sports participation. There is a current lack of injury epidemiological research within Ladies Gaelic football, particularly within adolescents, which is important for the development for specific injury prevention measures. Specific Gaelic football injury prevention programmes (IPP) have been developed, however, coaches' current use and attitude towards IPP implementation in Ladies Gaelic football are currently unknown.

Aims: In Ladies Gaelic football; (1) identify injury incidence, severity, location, nature and mechanisms in adolescents and (2) identify coaches' attitude towards, ability and willingness to implement IPP and current injury prevention implementation practices.

Methods: Injury epidemiology was collected prospectively by the primary investigator through weekly injury assessments with training logs self-completed weekly by players. Coaches' attitude towards IPP were gathered using an online survey. The online survey was validated using a three-round Delphi review process with a panel of experts.

Results: In study one an injury incidence of 10.32 injuries per 1,000 hours was observed with a greater injury incidence observed during match play than training (17.60 vs 5.83 injuries per 1,000 hours). Lower extremity injuries were predominant (70%), with the calf the most injured body part (30%). Over one-third of injuries resulted in more than 24 hours' time lost from participation. In study two, less than half of coaches (47.8%) reported using elements of IPPs, with the lack of coach knowledge and information (81.5%) the most commonly reported barrier to implementation. Coaches had a positive attitude and willingness to participate in IPPs for the majority, but less than a third (30.4%) of coaches had strong perceived ability to implement an IPP, particularly underage and club level coaches.

Conclusion: Injuries are an issue within adolescent Ladies Gaelic football, and although coaches are willing and have a positive attitude towards IPPs, the ability of underage and club level coaches to implement an IPP is limited. An injury prevention educational

programme for Ladies Gaelic football coaches should be developed to provide coaches with further information and training on implementing currently available IPPs that are accessible and practical without the need for additional equipment and facilities.

Author Declaration

I declare that I am the author of this thesis, that any work submitted is my own, that any data presented is accurate, were collected and analysed by myself and that appropriate credit has been given where references have been made to the work of others. This work has not in the same or altered form been presented to this institution or any other institution in support for any degree other than for which I am now a candidate.

Emma Ní Chaomhánaigh

Date

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Abbreviations

ACL- Anterior Cruciate Ligament

AE- Athletic Exposure

AU- Arbitrary Units

CI- Confidence Interval

GAA- Gaelic Athletic Association

IPP- Injury Prevention Programme

IR- Incidence Rate

LGFA- Ladies Gaelic Football Association

OR- Odds Ratio

PA- Physical Activity

PBC- Perceived Behavioural Control

RE-AIM- Reach, Effectiveness, Adoption, Implementation, Maintenance framework

RPE- Rate of Perceived Exertion

RR- Risk Ratio

TPB- The Theory of Planned Behaviour

TRIPP- Translating Research into Injury Prevention Practice

Y/o- Years Old or Year Olds

Conference Presentations

Oral Presentation;

Kavanagh E., O'Connor S., Moran K. & Ní Chéilleachair N. (2017), 'Epidemiology of injury in female adolescent Gaelic footballers in one season', FSEM Spring Study Day 2017, University College Dublin, Dublin. March 24th

Poster Presentation;

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Chapter 1

Introduction

1.1 Background and Rationale for Research

Participation in sports and physical activity (PA) has a variety of health-related benefits that may be physiological, skeletal, mental or social (Rössler et al., 2014). PA participation can have positive effects on cardiovascular diseases, diabetes mellitus, hypertension, cancer, bone and joint diseases, obesity, and depression (Warburton et al., 2006). Sports participation has also been associated with providing a positive pro-social environment where adolescents and children are exposed to basic values such as competitiveness, fair play, and achievement (Pate et al., 2000). Physical inactivity has also been acknowledged as one of the most important modifiable risk factors for reducing the obesity rate (Fox & Hillsdon, 2007). The National Teens' Food Survey (2008) showed that 14.7% of 13-17-year-old Irish females were classified as overweight and 3.2% were classified as obese. Reducing the rate of obesity is beneficial to not just the individuals concerned but to the economy, with obesity costing the Republic of Ireland €1.3 billion in 2009 (Perry & Dee, 2012). Participation in PA in Ireland is continuing to rise in adolescent females (Ipsos MRBI, 2016), with participation in team sports like Gaelic football increasing from 69.1% in 2013 to 75.6% in 2015. This increase in PA participation is a welcome trend for both the associated health benefits and financial benefits. However, participation in PA and sports involves an inherent risk for potential injury (Howard et al, 2014). Approximately one third (32.0%) of Finnish adolescents participating in PA (Räisänen et al., 2016) retrospectively reported sustaining an injury in the previous year and 74.3% of senior club level Ladies Gaelic footballers (Brown et al., 2013) reported sustaining an injury while participating in Ladies Gaelic football. The proportion of adolescent Ladies Gaelic footballers sustaining an injury and the burden of injury within adolescent Ladies Gaelic football is currently unknown.

Ladies Gaelic football is one of Ireland's national sports governed by the Ladies Gaelic Football Association (LGFA). Competitions for juvenile players are run at club, school and inter-county level. Juveniles are differentiated by age with U-10, U-12, U-14, U-16, and U-18 (also termed minor) competitions available. For adolescent players, in addition to club and inter-county competitions, post-primary school competitions are arranged on a national basis as well as the annual inter-provincial competition (Ladies Gaelic Football Association, 2017). Gaelic football is a team sport played for sixty minutes (two thirty-minute halves) and consists of two teams of fifteen players; a goalkeeper, six defenders, two midfielders and six forwards. There are two scoring methods, a goal which is equal

to three points and is scored when the ball crosses underneath the crossbar and between the posts past the goalkeeper, and a point which is scored when the ball crosses above the crossbar and between the posts (Reilly & Doran, 2001). Gaelic football has been described as a multi-directional, high-intensity, high- velocity, contact field sport, where speed, strength, and agility are required to perform the intermittent short and fast skills required to play the game, such as sprinting, turning, catching, jumping and kicking (Murphy et al., 2012). Due to the substantial physical contact, biomechanical stresses (acceleration, deceleration and turning at high speeds), in addition to repetitive vigorous bouts of effort, Gaelic football players are exposed to the risk of injury (Reilly & Doran, 2001; Wilson et al., 2007; Murphy et al., 2012).

An injury can be described as any mechanical disruption to normal healthy tissue resulting in pain (Kumar, 2001). During a traumatic event, the integrity of the injured tissue is violated, and its normal mechanical structure is disturbed (Kumar, 2001). Injuries occur when an energy, commonly mechanical energy, is transmitted to the body at amounts or rates greater than the threshold for damage to occur in normal human tissue (Meeuwisse et al., 2007). Injury thresholds differ depending on the type of tissue in question, the direction of the stress applied and the individual's skeletal structure, fitness levels and history of previous injury (McCaw, 2013). Gaelic football injuries can have negative effects and create a significant burden on players, negatively impacting the player's sporting and daily lives. This impact may be as a result of trauma, pain, loss of function, financial costs or psychological effects that occur due to injury which can also lead to time lost in both education and sport (Murphy et al., 2012; O'Connor et al, 2016). Sports-related injuries in adolescents may also prevent participation in future activities that may be beneficial to their overall health and well-being (Weber et al., 2016). Financial and resource burdens may also be placed on sporting organisations and the health care system as a result of sports related injuries, with the Gaelic Athletic Association (GAA) having to cover the deficit of injury scheme claims by using other sources of income which may have knock-on effects impairing funding for other projects and plans (Roe et al., 2016). Home, occupational, leisure and sports-related injuries across Europe account for 75% of non-admitted short-term patients presenting to emergency departments, 86% of total hospital costs and an average cost of €2,140 per admitted patient, highlighting the contribution that sports-related injuries have on both the financial and resource burden on the public healthcare system (Polinder et al., 2007; Polinder et al., 2005). The financial implications of sports related injuries resulting from injury treatments, time loss from

work and lengthy rehabilitation periods highlights the need for effective injury prevention strategies (Schlingermann et al., 2017).

van Mechelen (1987) initially described injury prevention strategies using a four-step process called the 'Sequence of Injury Prevention' (van Mechelen et al., 1992). The first and second step of the process involved establishing the injury incidence, severity, aetiology and mechanisms of injury followed by step three which involved introducing injury prevention measures and finally step four which mimicked step 1 establishing the effects of the injury prevention measure implemented in step three. The van Mechelen (1987) injury prevention sequence was then progressed by Finch (2006), in which a six-step process, the Translating Research into Injury Prevention Practice (TRIPP) model, was developed. The TRIPP model was progressed to include an evaluation stage of the impact the injury prevention strategy has in a real-world setting, in an attempt to provide the information required for direct injury prevention application and research into implementation issues previously encountered with proven effective programs (Finch, 2006).

There is a distinct lack of epidemiological research available for Ladies Gaelic football and adolescent Ladies Gaelic football specifically. Available research has been conducted on senior club Ladies Gaelic football retrospectively through the use of online questionnaires and insurance claim forms (Brown et al., 2013; Crowley et al., 2011). Injury severity, mechanisms of injury and injury onset types have not been identified in Ladies Gaelic footballers to date. Although research has been conducted on adolescent male Gaelic football (O'Connor et al., 2016), previous discrepancies in injury incidence an senior club level Gaelic football between male and female injuries have been identified (Crowley et al., 2011) which may be as a result of difference in playing rules (Buckley & Blake, 2018). These differences in injury incidence as a result of gender, in conjunction with the current gap in Ladies Gaelic football epidemiological research warrant further investigation into the potential differences between adolescent male and female Gaelic football as well as providing an understanding of the injury severity, mechanisms and onsets sustained by Ladies Gaelic footballers.

Injury prevention programmes (IPP) have been found to decrease the incidence and severity of lower extremity injuries and improve movement technique and performance (Martinez et al., 2017). Numerous IPPs have been established in an attempt to reduce the occurrence of injuries, particularly in children and adolescents participating in team sports

(Lindblom et al., 2018). Injury prevention measures have been developed specifically for Gaelic games; the GAA 15 and the Activate GAA Warm-Up. The GAA 15 has been shown to have both beneficial effects on neuromuscular outcomes such as dynamic stability and neuromuscular control (O'Malley et al., 2017; Schlingermann et al., 2017) and on reducing injury incidence by up 1.8- 2.9 times compared to a control of a standard dynamic warm up (Schlingermann et al., 2017; Kelly et al., 2017). IPPs that are well-designed have demonstrated lower incidence of injury and time loss from sport, however, these effects are strongly associated with the frequency of implementations, which places the focus for future clinicians and researchers on IPP implementation, use and adherence across all levels and age of sports (Ardern et al., 2018). Injury prevention compliance is not solely based on athletes' behaviours, but also requires support and behavioural changes from sports organisations, coaches, medical and healthcare professionals and other sports and exercise performance professionals (Vriend et al., 2017).

Team coaches are one of the main factors contributing to the adoption and implementation of IPP in amateur and underage levels of sport (Lindblom et al., 2018). Increased motivation by coaches may lead to an increase in compliance and adherence to the IPP, which leads to either the success or failure of an IPP implementation as compliance in particular is a crucial factor for IPP success (Martinez et al., 2017). Compliance is one of the primary barriers to IPP, however, the factors surrounding poor compliance are not fully understood (Martinez et al., 2017). While coaches may express an interest or intention to implement an IPP in conjunction with a positive attitude towards IPPs, the adoption and continued implementation of IPPs have been limited (Lindblom et al., 2017). Coaches' knowledge and beliefs about injuries do not directly translate into IPP adherence, in addition, IPP fidelity and following the IPP implementation dosage may also affect the levels of adherence to IPP (Lindblom et al., 2017). Implementation rates for IPP among high school coaches and adolescent girls' soccer coaches ranged from 19.8% (Joy et al., 2013) to 21% (Norcress et al., 2016), regardless of the high awareness of the potential injury prevention benefits among coaches. Despite the majority of male Gaelic football coaches agreeing that IPPs would reduce the risk of injury, only 7.7% of male Gaelic football coaches implemented the GAA 15 warm up (Reilly & Kipps, 2017). Although previous research has investigated the understanding and perception of injury prevention in male Gaelic football coaches, no research has examined the willingness and current IPP practices of Ladies Gaelic football coaches.

1.2 Importance of Research and Contribution to Knowledge

To date, no published research has examined musculoskeletal injury epidemiology in adolescent Ladies Gaelic football, with the majority of research conducted on males and elite males specifically (Murphy et al., 2012; Wilson et al., 2007; Newell et al., 2006). The injury incidence and characteristics gathered in this research project may provide valuable information in relation to medical care planning at both club and national levels by highlighting the potential injury, financial burdens and time lost from participation associated with injuries sustained while participating.

While previous research has examined male Gaelic football coaches' implementation and adoption of IPPs (Reilly & Kipps, 2017) current levels of injury prevention acceptance and implementation within Ladies Gaelic football coaches are currently unpublished. Coaches' awareness of available IPPs impacts IPP implementation and acceptance (Norcross et al. 2016). Thus, identifying Ladies Gaelic football coaches' current IPP knowledge may assist with the development of future educational programmes focused on the benefits and applications of currently available IPPs. Identifying Ladies Gaelic football coaches' current motives and barriers to implementing IPPs may also assist with the development of an IPP specific for Ladies Gaelic football that prioritises the issues and needs of Ladies Gaelic football coaches, in attempt to increase the uptake and implementation of IPPs among Ladies Gaelic football teams.

1.3 Aim, Objectives & Hypotheses

Chapter 3

The aim of this study is to prospectively identify the incidence and characteristics associated with musculoskeletal injuries in adolescent Ladies Gaelic footballers and retrospectively investigate the most severe injuries sustained and injury treatment and rehabilitation behaviours reported by adolescent Ladies Gaelic football while participating in all sports and PA in the previous year and.

Objectives:

- To prospectively establish musculoskeletal injury incidence in female adolescent Gaelic footballers.
- To prospectively identify the type, nature, location, onset, and severity of musculoskeletal injuries in female adolescent Gaelic footballers.
- To prospectively establish the injury outcome with regards to time lost from physical activity, sport, and school.
- To examine the training loads reported by adolescent female Gaelic footballers.
- To identify the location and severity of the most severe injuries sustained by adolescent females while participating in sports and PA in the previous year.
- To investigate the injury treatment and rehabilitation practices in adolescent females participating in sports and PA.

Hypotheses:

1. Injuries in adolescent Ladies Gaelic football will be prevalent.
2. Lower extremity injuries will be predominant in adolescent Ladies Gaelic football compared to upper extremity and spinal injuries.
3. Minor and moderate severity injuries will be more frequently reported than severe injuries.
4. Injured participants will report higher mean weekly training loads compared to uninjured participants.
5. Poor levels of injury treatment and rehabilitation will be observed for the most severe injury sustained by adolescent females.

Chapter 4

This aim of this study is to identify Ladies Gaelic football coaches' current injury prevention implementation practices and their attitude towards, ability to and willingness to implement injury prevention programmes (IPP).

Objectives:

- To investigate coaches' awareness of currently available IPPs.
- To examine coaches' current use of elements of injury prevention with their teams.
- To identify Ladies Gaelic football coaches' current attitude, understanding and use of IPP.
- To investigate the willingness of coaches to adapt their current practices to include an IPP and participate in injury prevention educational programmes and training.
- To examine potential barriers to implementation of IPPs with Ladies Gaelic football.
- To assess any relationships between the level and age of teams coached, and the barriers or willingness to implement IPP.
- To examine whether coaching qualifications and coaching experience within Ladies Gaelic football coaches, is related to injury prevention attitudes and ability.

Hypotheses:

1. Low awareness of currently available IPPs will be observed within Ladies Gaelic football coaches.
2. A small percentage of coaches will be implementing elements of injury prevention with their team.
3. Coaching qualifications will have a positive effect on coaches' attitude towards injury prevention and their perceived ability to implement an IPP.
4. Financial or educational barriers will be the most common barriers identified by coaches to IPP implementation.
5. Coaches' coaching adult or intercounty level teams will have greater perceived abilities to implement an IPP.

Chapter 2
Review of Literature

2.1 Introduction

The aim of this research study is to identify the incidence and characteristics associated with musculoskeletal injuries in adolescent Ladies Gaelic footballers and to investigate Ladies Gaelic football coaches' perception, experience and willingness to participate in injury prevention programmes. The purpose of this chapter is to provide a review of current relevant research supporting the concepts within this thesis. An introduction to physical activity and Ladies Gaelic football in Ireland and the associated benefits, potential risks and participation levels are initially established. Prevalent injury incidence and characterises for Gaelic football and adolescent female soccer, in addition to injury risk factors in adolescents will further be discussed. Finally, injury prevention in Gaelic games and coaches attitude towards injury prevention will be identified and discussed.

2.2 Physical Activity and Ladies Gaelic football in Ireland

2.2.1 Physical Activity

Physical activity (PA) has been defined as; 'any bodily movement produced by skeletal muscle that results in energy expenditure' (Caspersen et al., 1985, Pg. 126). There are numerous health-related benefits associated with participating in PA including; physiological, skeletal, mental and social (Rössler et al., 2014). Increased participation in PA is a known modifiable risk factor for reducing the risk of chronic diseases including; cardiovascular disease, hypertension, diabetes, colon and breast cancer, obesity, bone and joint disease (e.g. osteoarthritis and osteoporosis) and depression (Rössler et al., 2014). PA has the potential to reduce and prevent the obesity epidemic worldwide and can significantly reduce the disease risk for people who are overweight and obese, saving healthcare costs and reducing mortality rates (Lee et al., 1999). The National Teens' Food Survey (2008) showed that 14.7% of Irish 13-17-year-old females were classified as overweight and 3.2% were classified as obese when using the International Obesity Taskforce age and gender-specific body mass index ranges. There are huge financial burdens globally associated with obesity, wherein the Republic of Ireland (2009), the financial burden and cost of obesity was €1.3 billion (Perry & Dee, 2012). Only 12% (Woods et al., 2010) to 28.4% (World Health Organisation, 2010) of Irish adolescents achieve the recommended levels of PA a week. Irish male adolescents were also more likely to achieve the recommended levels of PA compared to their female counterparts (15% vs 9%) (Woods et al., 2010). A prominent gender gap for PA participation between

males and females was present between 12-13-year olds (11%) and 14-15-year olds (8%) (Woods et al., 2010). Participation rates for Irish female adolescents also declined with age, with a decline of 5% from 12-13-year olds to 14-15-year olds and a further decline of 2% from 14-15-year olds to 16-18-year olds (Woods et al., 2010).

Despite the many benefits associated with participation in PA, there is an inherent risk of injury (Howard et al., 2014). Injuries to children or adolescents, who are still growing with immature skeletons, can have long-term implications for health and function with severe injuries resulting in permanent disability (Dalton, 1992). The rates of sports and recreational injuries for adolescents and children presenting to emergency departments range from 21.1 visits per 1,000 persons aged between 10-18-years-old (Howard et al., 2014), to 33.9 visits per 1000 persons aged between 5-24-year-old (Burt & Overpeck, 2001). Sports and PA related injuries are one of the major public health problems seen due to their contributing social and economic burdens (Öztürk & Kılıç, 2013). Injuries are not only burdensome to the injured individual, but also their club, college, school or organisation, the team, the sport in general, and to the health services (Schlingermann et al., 2017; Polinder et al., 2016). Health care expenses generally have continued to rise throughout Europe over the past few decades, (healthcare expenditure as percentage of national income; 2005= 9.2%, 1990= ~7%, 1960= ~3.5%) increasing policy maker's interest in the cost related to injuries as well as the potential cost-effective savings associated with injury prevention programs (Erixon & Van der Marel, 2011; Polinder et al., 2016). The cost and strain on health care service and hospital emergency departments due to sports related injuries can also be significant, with 15.5% of Scottish adolescents reported being admitted for an overnight stay in the hospital and 54.4% of adolescent reporting time missed at school due to an injury (Williams et al., 1998). Costs of injuries may depend on the degree and quantity of health care services used, resources used to diagnose and detect injuries and the cost of treatments. Home, leisure and sport injuries accounted for 75% of non-admitted patients presenting short-term in emergency departments across Europe, with home and leisure, sport and occupation injuries accounting for 86% of total hospital costs in Europe and an average cost of €2,140 per admitted patient (Polinder et al., 2007 and Polinder et al., 2005).

The burden of injury for an individual is multifactorial and can include; physiological, psychological, personal and financial burdens. Injuries can affect PA participation or sporting performance as well as basic activities of daily living like walking, driving or

lifting (Roos et al., 1998). The potential long-term symptoms and disability associated with sports-related injuries in childhood or adolescence include; pain on rest, pain with exercise, unsteadiness, limited joint mobility, weakness, paraesthesia, scarring and recurrent oedema (Marchi et al., 1999). Sports-related injuries can also have financial burdens on the sporting organisation. Over an 8-year period, a €64,733,597 (Annual average cost €8,091,699) injury claim cost for the GAA from 58,038 claims (adults- 85.7% and youths- 14.7% of claims) was reported (Roe et al., 2016). The majority of the costs for the injury claims are covered by the fee generated from the clubs, gate receipts at matches, accumulated interest and GAA funding, which is a significant financial burden to the amateur GAA organisation and may limit further investment in the GAA nationwide (Roe et al., 2016). Similarly, in New Zeeland Rugby League injury claims had an annual cost of $5,352,760. The rate of injury for 10-14-year-olds was 15.8 per 1000 claims ($325,440 total cost) and for 15-19-year-olds rates were 142 per 1000 claims ($4,479,520 total cost) (King et al., 2009).

A balance must be achieved between the financial cost of physical inactivity observed in Irish adolescent females as a result of low and further declining PA participation levels, and the financial burdens associated with injury as a result of increased PA participation. The identification of injury trends and patterns within active Irish adolescent females may assist with the development of a structured injury prevention programme to allow for long term participation as well attempting to reduce the financial burden associated with injury for players, club, sporting organisations and the healthcare system overall. Additionally, an educational programme for Irish adolescent females into the benefits associated with injury prevention programme participation in attempt to increase participation for those in fear of injury or who may have dropped out of participation as a result of injury and fear or re-injury must be considered to increase the overall participation in PA for long-term health benefits.

2.2.2 Ladies Gaelic Football

Gaelic football is one of a group of sports indigenous to Ireland, which also includes; hurling, camogie, handball and rounders (Beasley, 2015; Reilly & Doran, 2001). Ladies Gaelic football is one of the fastest growing sports for females in Ireland and is also being played on an organised basis in Africa, Asia, Britain, Canada, Mainland Europe, New Zeeland, South America and America (Liston, 2006 b; Ladies Gaelic Football Association, 2017). Ladies Gaelic football has an Irish playing population of between 130,000 (Liston, 2014) and 150,000 players (Crowley et al., 2011). The aim of ladies Gaelic football is to outscore your opposition (Wilson et al., 2007). A team has scored a point when the ball has travelled above the crossbar and between the posts or a goal, which is equal to 3 points, when the ball travels under the crossbar, past the goalkeeper and into the net (Wilson, et al., 2007; O'Connor et al., 2017; Murphy et al., 2012; Roe et al., 2016).

The Ladies Gaelic Football Association (LGFA), also known as Cumann Peil Gael na mBan, was established in 1974 and received their formal recognition from the Gaelic Athletic Association, the governing authority in 1982 (Bourke, 2003; Liston 2006 a; Ladies Gaelic Football Association, 2017). The LGFA is an all-island organisation that runs competitions at national and interprovincial levels for juvenile players, adult players, post-primary schools and third level colleges (Liston, 2014; Bourke, 2003; Ladies Gaelic Football Association, 2017). Specifically, for juvenile players, county level competitions are organised at U-14, U-16 and U-18 levels, as well as post-primary school competitions and the annual interprovincial competition (Ladies Gaelic Football Association, 2017). It is possible that players may be participating in more than one age category at club level as well as potentially participating for their school and county team, which may place these players at a greater risk of sustaining an injury as they are participating on multiple teams simultaneously (Kelly & Lodge, 2018), potentially resulting in a greater exposure time to injury risk factors, increased training loads and reduced recovery periods.

From U-14 on, ladies Gaelic football is played on a full-size GAA pitch, which has a width of 80-90 meters and a length of 130-145 meters, which is ~40% larger than a standard soccer pitch (Ladies Gaelic Football Association, 2016; Beasley, 2015; Reilly & Doran, 2001). Ladies Gaelic football is played using a size 4 football from U-11 to adult levels and competitive matches from U-14 to adult level have a duration of 30 minutes per half with an interval at halftime not exceeding 15 minutes (Ladies Gaelic Football Association, 2016). There are minor differences between the playing rule of men's Gaelic

football and Ladies Gaelic football (Crowley et al., 2011; Brown et al., 2013). Although both sports are classified as contact sports, in the ladies' game deliberate body contact, for example, shoulder charging, is forbidden and tackling or pressuring a player in possession may be done by fielding and shadowing (Crowley et al., 2011; Brown et al., 2013). Another important difference is that ladies can directly raise the ball from the ground using the hand, whereas men must raise the ball from the surface using their foot (Brown et al., 2013).

Gaelic football has been described as a high-intensity and multidirectional running field sport, that require physiological attributes such as speed, endurance, strength and agility (Schlingermann et al., 2017; Roe et al., 2018). Physical and biomechanical demands such as jumping, catching, pivoting, sprinting, kicking performed at speed intermittently can affect a player's risk of injury (Wilson et al., 2007; Schlingermann et al., 2017). The explosive efforts completed during jumping, sprinting, turning and landing requires power and strength from the neuromuscular system, and when combined with the multidirectional and contact nature of the game particularly during match play, results in a high risk of injury (O'Malley et al., 2017). The demands on players to perform repeated explosive efforts throughout the duration of a game, depending on the player's physical conditioning can result in a player performing in a fatigued state increasing their risk of injury (Newell et al., 2006) through aberrant biomechanics, compromised perceptions, poor movement patterns and reduced decision-making ability (Borotikar et al., 2008). In elite male Gaelic football, the highest physical demand is on the aerobic system and also an emphasis is placed on the technical skills of the games (Reilly et al., 2015). Elite male Gaelic footballers are required to perform longer high-intensity bouts with shorter recovery periods than professional soccer players (Reilly et al., 2015), which may contribute to the earlier onset of fatigue placing Gaelic football players at greater risk of injury (Newell et al., 2006) through the mechanisms identified above. In youth elite male Gaelic footballers (15 ± 0.66 years-old) the mean distance covered during matches was 5,732 meters (± 1,047m) with a mean of 851m (± 297m) high-intensity distance completed (Reilly et al., 2015). The mean heart rates for male elite youth Gaelic footballers during matches was 166 bpm (± 11 bpm) with midfielders (173 ± 9bpm) and halfbacks (171 ± 10bpm) showing higher average heart rates than fullbacks (161 ± 13bpm), half forwards (162 ± 12bpm) and full forwards (164 ± 7bpm) (Reilly et al., 2015).

2.3 Injury Epidemiology: Theory and Challenges

2.3.1 Injury Epidemiology & Frameworks for Injury Prevention

Injury epidemiological research in sporting populations is important to monitor sports-related injury trends and patterns over time that may provide an understanding and insight into the relationship between increases in sports and PA participation and changes in injury patterns and trends (Finch, 1997). With the provision of a greater understanding and insight into injury patterns, distribution and aetiology, the development of successful strategies aimed at reducing injury occurrence and severity are possible (MacKenzie, 2000). There are challenges, however, with transferring this knowledge into effective prevention programs that are economically, socially and politically acceptable and sustainable (MacKenzie, 2000). Specifically, epidemiological research into the incidence and determinants of injuries is critical for the identification and subsequent evaluation of interventions such as; the use or development of protective equipment, modifications to match rules and regulations and the planning of medical resources required specifically for different sporting events (Finch, 1997).

Van Mechelen et al. (1992) highlight the importance of epidemiological research through the 'sequence of prevention', contributing to the creation of effective injury prevention strategies (Figure 2.1). The 'sequence of prevention' begins by recognising and describing the sports injury problem. The second step further investigates the factors and mechanisms that may be contributing to the sports injuries with step three using the information gathered from step one and two to introduce an injury prevention strategy aimed at reducing the future risk of injury and/ or the severity of future injury. The final step four involves evaluating the effectiveness of the injury prevention strategy by reapplying the same process as step one.

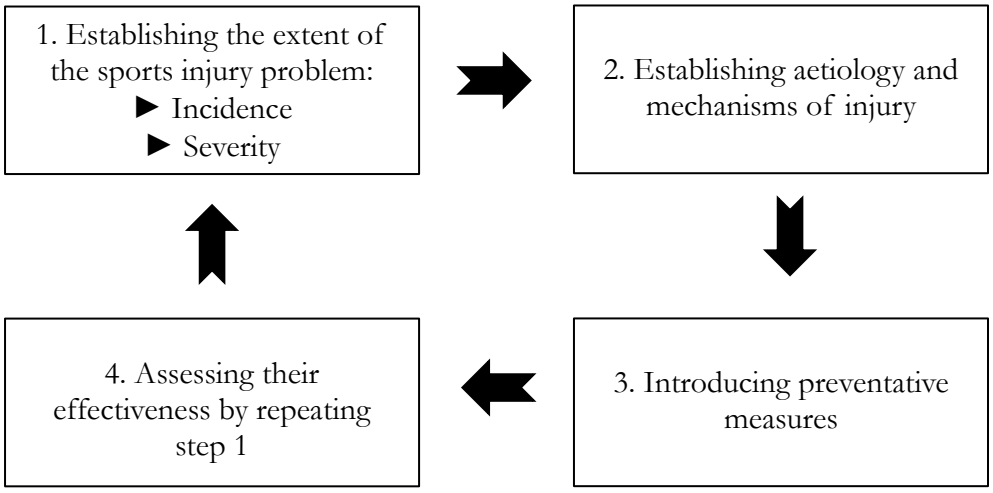

Figure 2.1: The 'Sequence of Prevention' for sports-related injuries (van Mechelen et al., 1987 in van Mechelen et al., 1992)

Policy-makers are increasing their interest in injury prevention strategies as a cost-saving measure (Polinder et al. 2016). Sports injury epidemiological data has the potential to inform the planning and allocation of medical resources. Such epidemiological data may contribute to prevention strategies resulting in a reduction in sports-related injury incidence, the reduction of healthcare costs and potentially reducing the loss of productivity associated with injuries (Polinder et al., 2016). The economic cost associated with injury can be utilised as a comparable outcome measure for identifying differences in injuries in incidence, severity, disability and healthcare needs, which may allow policymakers to prioritise the development of certain preventative strategies and trauma care resources. The severity of injury may also influence the financial burden of injury, with some severe injuries ranging beyond pain and discomfort potentially resulting in greater healthcare demands and absenteeism from work (Cumps et al., 2008).

Several limitations to the van Mechelen et al., (1992) model were identified by Finch (2006) leading to the development of the 'Translating Research into Injury Prevention Practice' (TRIPP) framework (Figure 2.2). The failure to sufficiently detail information needed to research the factors leading directly to injury prevention was one of the main limitations identified (Finch, 2006). The lack of consideration towards researching implementation issues encountered post injury prevention protocol/strategy development and testing, in conjunction with the lack of consideration to the comprehension of the determinants and influences of sport safety behaviours are further limitations noted (Finch, 2006). The lack of consideration and knowledge into the uptake

and compliance to preventative methods may be a significant factor in the negative or insignificant effects observed from previously conducted research where injury preventions strategies were implemented (Finch, 2006). The first four stages in TRIPP are similar to that of the Sequence of Prevention model above, with the addition of Stages 5 and 6. Stage 5 entails evaluating the potential application of the protocol or strategy, into a sporting condition and the attitude and potential compliance by both players and coaches alike. Stage 6, involves the implementation of the injury prevention intervention into the sporting environment, and the evaluation of its effectiveness by establishing how applicable a scientifically proven and developed intervention protocol can be when applied to a real-life sporting environment where sporting culture and player behaviours may intervene. The epidemiological study in chapter three aims to focus on steps 1 and 2 of the sequence of prevention or steps 1 & 2 of the TRIPP framework, with the coaches' perception of injury prevention study in chapter four focused on step 5 of the TRIPP framework.

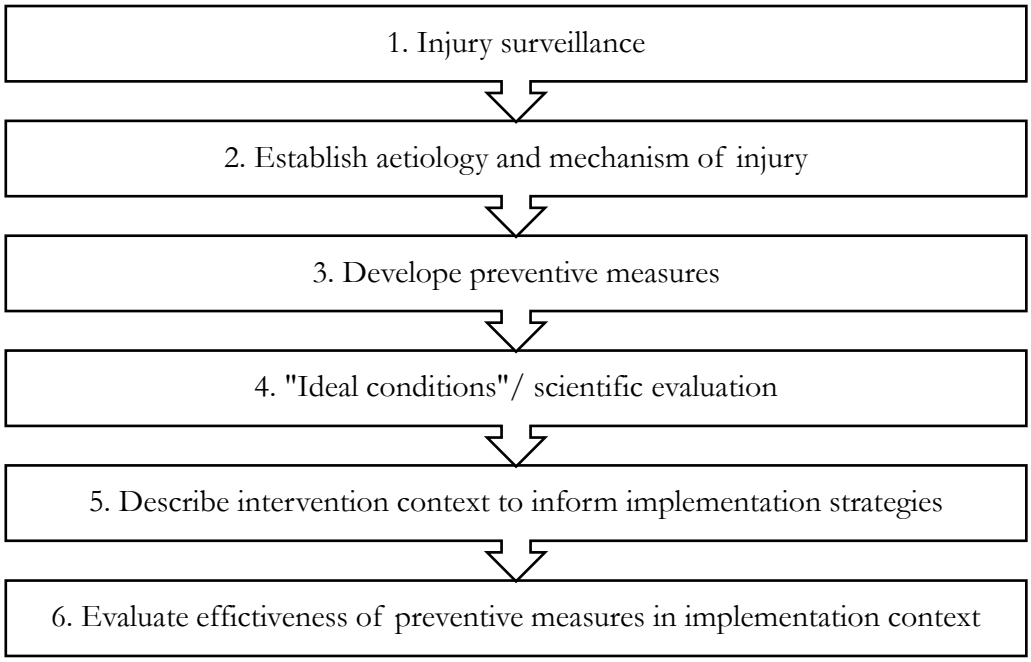

Figure 2.2: The TRIPP framework for sports injury prevention (Finch, 2006)

The Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework (Table 2.1), emphasises the reach and representativeness of both participants and settings on public health, or in this instance injury prevention, implementation strategies (Glasgow et al., 1999; Donaldson & Finch, 2012). In particular, for sports-based interventions the RE-AIM demonstrates the array of factors influencing the uptake of sports-based interventions (Donaldson & Finch, 2012). The RE-AIM framework is of particular use during the evaluation of sports injury prevention interventions as it provides insights and cues into the complexity of the implementation contexts (Finch & Donaldson, 2010). The first phase reach of the framework is an individual level measurement of participation that refers to the proportion and risk characteristics of participants participating in or effected by a programme (Glasgow et al., 1999). The effectiveness phase of the framework investigates the successful implementation of a programme compared to the intended method of implementation by individuals in a real-world setting away from a controlled research environment and must consider both the positive and negative outcomes as a result (Finch & Donaldson, 2010; Glasgow et al., 1999).

Adoption and implementation are conducted at organisation level, where adoption looks at the proportion and representativeness of settings (e.g. organisations, clubs or county boards for Gaelic games injury prevention strategies) that adopt a programme (Glasgow et al., 1999). Adoption can be assessed by direct observation or structured interviews and surveys, where assessing the barriers to adoption is equally as important in nonparticipating settings (Glasgow et al., 1999). Implementation considers the effectiveness of an implementation program in a real-world setting based off the accuracy of implementation as intended and is vitally important in identifying interventions that are practical to implement for their representative setting (Glasgow et al., 1999). Maintenance evaluates the extent to which the injury prevention programme becomes habitual and part of the organisation's normal practice and has been identified as one of the major challenges for long-term intervention at both an individual and organisational level (Glasgow et al., 1999). The current study in chapter four looks at coaches' perceptions and understanding of IPPs, similar to the reach and effectiveness phase of the RE-AIM framework, the study aims to look at current uses or implementation rates of available IPPs and the barriers to implementation.

Table 2.1: The RE-AIM Framework in Sports Settings (Glasgow et al., 1999; Finch & Donaldson, 2010)

Dimension	Definition	Level
Reach	Proportion of the target population that participated in the intervention	Individual
Effectiveness	The success rate if implemented as in guidelines; defined as positive outcomes minus negative outcomes	Individual
Adoption	The proportion of settings, practices, and plans that will adopt this intervention	Organisation
Implementation	The extent to which the intervention is implemented as intended in the real world	Organisation
Maintenance	The extent to which a program is sustained over time	Individual & Organisation

2.3.2 Challenges with Injury Epidemiology

There are a number of limitations to previous injury epidemiological studies in sporting populations to date including; varying research designs, varying injury and injury severity definitions, differing data collection methods, differences in the data collected and different data analysis methods (Finch, 1997; Brooks & Fuller, 2006).

2.3.2.1 Differing Injury Definitions

One of the major difficulties observed while attempting to compare data is the differing injury definitions which may contribute to different incidences observed (van Mechelen, 1992). Injury definitions can be dependent on the time after the onset of pain, commonly 24 hours (Murphy et al., 2012), 48 hours (Newell et al., 2006) or one match or training session missed (Wilson et al., 2007) (Table 2.2). In addition, other definitions have no time restriction associated with their injury definition in an attempt to collect all performance limiting injuries (O'Connor et al., 2016; O'Connor et al., 2017; Cromwell et al., 2000) while some injury definitions include the requirement for medical treatment or intervention (Wilson et al., 2007). The injury definition used in the current study is the same as the injury definition adopted by O'Connor et al. (2016) while investigating the epidemiology of injury in adolescent male Gaelic footballers and hurlers. The same injury definition was adopted as O'Connor et al. (2016) to allow for direct comparison of adolescent Ladies Gaelic football epidemiological data collected to the most recently available for adolescent males. The O'Connor et al. (2016) injury definition was also

selected for use in adolescent Ladies Gaelic football as it included all injuries that may result in time loss or restricted performance, to include minor injuries that may not require medical intervention, as it has previously been identified that not all adolescent injuries require medical intervention but may effect participation (Kelly & Lodge, 2018).

Table 2.2: Variations in Gaelic Football Injury Definitions used in Previous Research

Author	Level	Injury Definition
O'Connor et al. (2017)	Collegiate Male	Any injury sustained during training or competition resulting in time lost from play or athlete reported restricted performance
O'Connor et al. (2016)	Adolescent Male	Any injury sustained during training or competition resulting in restricted performance or time lost from play
Murphy et al. (2012)	Elite Senior Male	Any injury that prevents a player from taking a full part in all training and game play activities typically planned for that day, where the injury has been there for a period greater than 24 hours from midnight at the end of the day that the injury was sustained
Wilson et al. (2007)	Senior Male Club	One that caused a player to miss one training or game or that required at least one treatment
Newell et al. (2006)	Elite Senior Male	A player was considered injured if he was unable to participate fully in training or games for a period of at least forty-eight hours after the injury was sustained
Cromwell et al. (2000)	Elite Senior Male	One sustained during training or competition resulting in restricted performance or time lost from play
Watson (1996)	Secondary School Male	The investigation was not restricted to injuries that required medical treatment or that prevented participation in football completely. It included injuries that restricted activity to any significant, specified, extent

2.3.2.2 Differing Injury Severity Definitions

Another common variation observed while comparing sports-related injury research is the definition and classification of injury severity. The main differences in the injury severity definition surround the set endpoint of an injury. Injury severity may be defined as the number of days elapsed from the initial day of injury to either return to full participation in training and available for match selection (Newell et al., 2006) or until the player reached full fitness (Murphy et al., 2012). The differences between both of the

definitions may alter the severity rating of an injury as a player may not reach full fitness but return to training and participate in matches or competition.

The classifications of injury severity also vary which can lead to further difficulties while comparing data. The majority of Gaelic football studies used a three-level classification system apart from Wilson et al. (2007) who included a fourth level, an injury classification that described a season-ending injury. The duration for the different levels may also vary with the first level duration described as 1-7 days (Murphy et al., 2012; Wilson et al., 2007), <7 days/<1 week (Newell et al., 2006; O'Connor et al., 2016; O'Connor et al., 2017) and ≤7 days (Cromwell et al., 2000). The duration for moderate injuries also varied from 8-21 days/1-3 weeks (O'Connor et al., 2016; O'Connor et al., 2017; Wilson et al., 2007; Newell et al., 2006) and 8-27 days (Murphy et al., 2012; Cromwell et al., 2000). Severe injury durations varied from >21 days/ >3 weeks (O'Connor et al., 2016; O'Connor et al., 2017; Wilson et al., 2007; Newell et al., 2006) and >28 days (Murphy et al., 2012; Cromwell et al., 2000). Similar to the injury definition selected for the current study, the injury severity classification system selected was the same as that used for the most recent male adolescent Gaelic football (O'Connor et al., 2016) research to allow for direct comparisons to be made. The injury classification system selected for use was also one of the most commonly reported within the available Gaelic football research.

2.3.2.3 Differences in Data Collected

Injury surveillance systems collecting injury epidemiological data and outcomes should be completed in a method that is relevant and interpretable for a broad range of potential users including; participants themselves, sports administrators, sporting organisations, coaches/ managers/ trainers, healthcare professionals, government agencies and researchers (Finch, 2006). For the data collected to achieve this aim of relevancy and interpretability, Finch (1997) suggested that all data collection systems should include at least the specific set of question, found in Table 2.3 below.

Table 2.3: Important data collected in injury surveillance research (Finch, 1997)

Question	Example Answer
The sport/PA engaged in at the time of the injury	Football
The location where the injury was incurred	Local football pitch
The particular activity initiating the injury	Sprinting
What went wrong?	Collided with another player
The level of supervision of the initiating activity	Recreational
The nature of the injury	Sprain
The body region(s) injured	Head
The severity of injury	Time lost from activity
Characteristics of injured person	Age
Places of presentation and referral for treatment	Physiotherapist
Sports participation data	Number of training/game hours
The use of sports injury countermeasures	Protective equipment

2.3.2.4 Differences in Data Collection Methods

The methods for data collection also vary and may affect the comparative ability of published research. Data collection can be completed either retrospectively or prospectively using different methods such as medical records or hospital charts, questionnaires, interviews, self-reporting via email or text, and team physician or therapist examinations, recording and reporting.

The perception of injury differs between athletes, medical/healthcare professionals and coaches. Athletes displayed significantly lower ratings for the levels of disruptive impacts that injuries had, compared to medical professionals ($p< 0.01$) as well as underestimating the short-term effects of an injury ($p< 0.05$) (Crossman et al., 1990). In addition, coaches rated the seriousness of injuries to their athletes significantly higher than that of the medical professionals ($p< 0.01$) and overestimated the disruptive effects that injuries had for higher level athletes and athletes who had never sustained a serious injury (Crossman et al., 1990). These significant differences between athletes, medical/healthcare professionals and coaches' perception of injuries and injury outcomes may alter the accuracy of data recorded and reported.

There are benefits and limitations associated with the use of medical and healthcare professionals as a method of data collection. Data collected by healthcare professional has commonly been reported and used in Gaelic games research (O'Connor et al. 2016; Schlingermann et al., 2017) as it allows for the reporting of more detailed injury data when

compared to emergency departments, sports clinics or GPs, and also facilitates the gathering of exposure level data which is important for data analysis (Goldberg et al., 2007). However, when compared to emergency departments or sports clinics, healthcare professionals may not have access to on-site diagnostic equipment which may lead to a less precise diagnosis. In addition, depending on the age, participation level and sport, access to healthcare professionals may be limited, and the qualifications of healthcare professionals vary (Goldberg et al., 2007). One of the main challenges with using medical/healthcare professionals for injury surveillance systems is compliance (Bjørneboe et al., 2011). Medical/ healthcare professionals underestimated injury incidence by 19% over a 3-month period, but on the other hand 30% of injuries logged by the medical staff were not recalled by players after the 3 months, potentially indicating a significant recall bias with the use of retrospective player interviews as a method of injury surveillance (Bjørneboe et al., 2011). Restricting the period of time that participants are asked to recall injuries may reduce recall bias, as previous studies have shown the longer the duration since the injury occurred the greater the reduction in recall accuracy (Gabbe et al., 2003; Bjørneboe et al., 2011). While medical/healthcare professionals may have a better rapport with players who have greater confidence in them, this close involvement with the team may also have an adverse effect and conflict of interest as they may not be an independent observer from a scientific viewpoint (Junge & Dvorak, 2000). Although the use of medical/ healthcare professionals may be beneficial for diagnostic accuracy compared to player or coach reporting, the personal interpretations by medical/ healthcare professionals may lead to systematic bias as a result of their qualifications and levels of experience and exposure (Clarsen & Bahr, 2014). Data collected from injury surveillance systems also can contain multiple sources of potential errors including; inappropriate or incorrect use of coding response classifications, misdiagnosis of injuries logged, failure to fully complete all data fields provided, data logging mistakes or missed or forgotten cases not logged (Ekergren et al., 2016).

Emergency department records may also be utilised as a method of data collection with injury incidence studies (O'Rourke et al., 2007). The use of such records may be a helpful resource for severe or acute sports injury data that represents a small proportion of all sports-related injury cases (Goldberg et al., 2007). However, emergency department medical records may result in the over-representation of male sports-related injuries, acute or severe injuries and sports-related injuries in youths (Goldberg et al., 2007). In addition, only 28% of participants with participation restrictive injuries attended an emergency

department due to injury (Nicholl et al., 1991). In fact, previously published research using emergency departments and sports injury clinic figures may be misleading as 51.7% of all self-reported injuries via questionnaire received no treatment or 2.3% were self-treated (Nicholl et al., 1991). Therefore, to collect extensive data for sports-related injuries that incorporates mild and moderate injuries or non-traumatic injuries, specifically for the general community, injury data should be gathered from healthcare professionals (Valuri et al., 2005; Ekergren et al., 2016). The use of independent investigators reviewing video analysis of competitions has also been suggested as an objective measurement of injury reporting (Junge & Dvorak, 2000). However, while this method may provide a low-cost visual representation of the injury occurrence and mechanism it is limited to only reporting the frequency of injury as there is no access to the results of the medical diagnosis (Junge & Dvorak, 2000). In addition, it is possible that not all injuries are recorded, especially those occurring during training (Hawkins & Fuller, 1998; Junge & Dvorak, 2000).

Recently the use of phone text messaging methods for injury and exposure data collection have been used in injury surveillance research. Text messaging systems have previously been used in elite female soccer and compared it to the standard medical team reporting of injuries (Nilstad et al., 2014). Text messaging system required players to provide match and training exposures and to report any injury or illness sustained throughout the week. Of the injuries reported by players, medical staff only reported 44% of all match injuries sustained and failed to record up to half of all acute, and two-thirds of all overuse injuries reported through the text messaging system (Nilstad et al., 2014). The authors concluded that the text messaging system for reporting injuries by players themselves appeared to be a feasible and convenient method and tool for researchers for registering injuries throughout a full season, as well as reducing the overall burden on healthcare professionals when reporting data (Nilstad et al., 2014). Some of the main proposed benefits of the text messaging system include; user-friendly for players, quick completion and ease of access as no direct in-person contact with the players or internet access were required, potentially explaining the high response rate (90%) (Nilstad et al., 2014).

Retrospective questionnaires are a popular method of data collection within sports epidemiological research as they are time and resource efficient particularly with large sample sizes and they have also been associated with increased athlete response and compliance (Mukherjee, 2015). Recall errors are the main limitations to the use of retrospective questionnaires (Fuller et al., 2006) as the majority of retrospective

questionnaire require participants to self-report data based on their memory and ability to accurately recall information (Mukherjee, 2015; Gabbe et al., 2003). A biased result towards recalling severe injuries and an underreporting of minor injuries within injury epidemiological research is a common issue encountered with retrospective questionnaires (Mukherjee, 2015). All community level Australian footballers were able to report whether they sustained an injury over the previous 12 months, however, just over three-quarters of players were able to report the number of injuries or the regions of the injuries sustained with less than two-thirds of players were able to report the number of injuries they sustained, their location and diagnosis (Gabbe et al. 2003). Similarly, less than two thirds of injuries prospectively reported in physical education students were retrospectively reported the following year, where a bias towards injuries with a greater duration of symptoms and the need for further assessments or interventions were more commonly reported (Twellaar et al., 1996), supporting the theory that severe injuries are more commonly reported and minor injuries may be underreported (Mukherjee, 2015). In an attempt to reduce the recall bias observed with the use of retrospective questionnaire it has been suggested that the questionnaire should; be context or sports specific, have clear and specific injury definitions, have limited recall times, be physically distributed with the researcher present and contain an image and list of anatomical locations to assist with injury region identification (Gabbe et al., 2003; Mukherjee, 2015; Mukherjee et al., 2014).

There are both advantages and disadvantages to the use of any injury surveillance system. The most effective methods for data collection in young athletes depends on the overall structure of the youth sport, who is and what qualification does the individual that provides the initial care to most of the athletes (e.g. emergency rooms or medical/healthcare professionals), and the presence or absence of national injury surveillance systems or databases (Goldberg et al., 2007). In addition, injury surveillance systems should be tailored to the requirements of each individual sport and may be dependent on the availability of medical and healthcare professionals (Bjørneboe et al., 2011). Prospective data collection by a medical/ healthcare professional would be the most appropriate method of data collection in adolescents as it was shown to be more accurate than player or coach reporting who have limited knowledge on sports related injuries, the age of the participants and their limited access to a medical/ healthcare professional with their team and overall to allow for standardised detailed data collection completed by one professional throughout the duration of the study.

2.3.2.5 Variations in Data Analysis and Data Reporting

One difficulty encountered while attempting to compare data and in particular injury incidence data is the different measurement units used i.e. hour's exposure and athletic exposures. An athletic exposure can be defined as one participant participating in one training or competition regardless of the duration, where they are exposed to a potential sports-related injury (Dick et al., 2007). In comparison, the hour's exposure ensures the exact duration of each training session or competition is taken into consideration and commonly analysed to a rate per 1,000 hours' exposure. Injury incidence per 1,000 hours was chosen as the methods of analysis in the current study as it is deemed a more accurate measurement with specific exposure durations taken into consideration compare to the number of exposures regardless of duration per 1,000 AEs.

The duration of the observation may also affect the data collected, creating difficulties while attempting to interpret and compare results, with some studies reporting injuries from one tournament alone and others reporting a full season or part of a season. Due to the differences commonly observed between training and competition injury incidences, particularly in Gaelic football (O'Connor et al., 2017; Murphy et al., 2012; Wilson et al., 2007), the duration and timing of the observation period may be biased, based off the different exposure rates to both training and matches throughout different times of the season, potentially influencing the injury incidences reported (Junge & Dvorak, 2000; Brooks & Fuller, 2006).

2.4 Epidemiology of Injury in Adolescent Female Soccer and Gaelic Football

There is a distinct lack of epidemiological research available for Ladies Gaelic football, with no published research currently available for adolescent Ladies Gaelic footballers. As a result of this lacking or non-existing research in Ladies Gaelic football, the epidemiology of injury for female adolescent soccer players, the available Ladies Gaelic football research and male Gaelic football research will be reviewed. Adolescent female soccer was chosen as a comparison to adolescent Ladies Gaelic football as they are both multidirectional team field sports that require elements of kicking, sprint and jumping.

2.4.1 Injury Incidence

Injury incidence can be expressed in multiple ways including incidence proportions, incidence rates, clinical incidence and injury prevalence. Injury prevalence is used to measure and describe the proportion of players who have an existing injury at a specific time and injury incidence measures the number of new injuries reported over a specific timeframe (Knowles et al., 2006 b). Incidence rate measures the number of injuries per units of person-time which can be per hour or athletic exposure (Knowles et al., 2006 b). Incidence proportion measures the average risk of injury by dividing the number of injured players by the total number of players at risk (Knowles et al., 2006 b). Clinical incidence is used to measure the average number of injuries sustained per player (Knowles et al., 2006 b).

2.4.1.1 Injury Incidence in Adolescent Female Soccer

There is a distinct lack of injury incidence research for adolescent females in Ireland with no previously published research available for adolescent Ladies Gaelic football. However, a wide variety of research has been completed internationally on multiple sports, with female soccer (Le Gall et al., 2008; Clausen et al., 2014; Emery et al., 2005 b; Söderman et al., 2001 a; Sentsomedi & Puckree, 2016) the most commonly researched sport. Injury incidence for adolescent female soccer varies greatly by geographical location, level of play and age of participants, with overall injury incidences ranging from 90.0 per 1,000 AEs (Sentsomedi & Puckree, 2016) to 2.35 per 1,000 AEs (Knowles et al., 2006 a) (Table 2.4). Higher injury incidence in matches than training (Barber-Foss et al., 2014; Le Gall et al., 2008; Comstock et al., 2006; Powell & Barber-Foss, 1999) is commonly observed, potentially due to the increased intensity during matches.

Table 2.4: Injury Incidence Rates for Adolescent Female Soccer

Study	Sample Size (n)	No. of Injuries	Injury Rate					
			Per 1,000 hrs			Per 1,000 AEs		
			O	T	C	O	T	C
Sentsomedi & Puckree (2016)	85	80	-	-	-	90.0	-	-
Beachy & Rauh (2014)	666	165	-	-	-	3.19	3.21	3.11
Barber Foss et al. (2014)	26	12	-	-	-	6.66	5.27	9.05
Clausen et al. (2014)	498	424	15.3	-	-	-	-	-
Le Gall et al. (2008)	119	619	6.4	4.6	22.4	-	-	-
Knowles et al. (2006 a)	748	121	-	-	-	2.35	-	-
Comstock et al. (2006)	-	-	-	-	-	2.36	1.10	5.21
Emery et al. (2005 b)	164	39	5.62	2.65	8.55	-	-	-
Söderman et al. (2001 a)	153	79	6.8	-	-	-	-	-
Powell & Barber-Foss (1999)	6,642	1,771	-	-	-	5.3	3.1	11.4

O: Overall rate, **C**: competition rate, **T**: training rate, **AE**: Athletic Exposure, **Hrs**: hours, **-** : not reported/available

2.4.1.2 Injury Incidence in Gaelic Football

Limited research is currently available on the injury incidence in Gaelic football, particularly in adolescents and Ladies Gaelic footballers, with the majority focusing on male Gaelic footballers, particularly elite players (Murphy et al., 2012; Newell et al., 2006; Cromwell et al., 2000). The retrospective nature of the available research for senior club Ladies Gaelic football results in a limited injury incidence data available (Brown et al., 2013; Crowley et al., 2011). Crowley et al. (2011) retrospectively investigated club level Ladies Gaelic football injury incidence through the analysis of insurance claim forms submitted through the Injury Insurance Scheme. An injury incidence of 2.4 injuries per 1,000 hours in club level Ladies Gaelic footballers was observed (Crowley et al., 2011), which was substantially lower than male club level Gaelic footballers, 8.25-13.5 injuries per 1,000 hours (Crowley et al., 2011; Wilson et al., 2007). However, since this study utilised insurance data, minor injuries may be excluded, with a focus on major injuries requiring further investigations or treatment. A retrospective analysis of American club

level Ladies Gaelic football injuries found that 74.3% of participants reported sustaining an injury while participating in Ladies Gaelic football (Brown et al., 2013). The percentage of injured participants in club level Ladies Gaelic football (Brown et al., 2013) was greater than that observed in male adolescent footballers and hurlers (32.5%) (O'Connor et al., 2016), collegiate males (47.5%) (O'Connor et al., 2017) and elite males 66-69% (Newell et al., 2006; Murphy et al., 2012). However, the retrospective online questionnaire was unable to capture Ladies Gaelic football exposure level preventing the calculation of injury incidence.

In addition to elite or senior club male Gaelic football, one study investigated the injury incidence in adolescent Gaelic football (O'Connor et al., 2016), schools Gaelic football (Watson, 1996) and collegiate Gaelic football (O'Connor et al., 2017) (Table 2.5). Adolescent males (4.89 injuries per 1,000 hours) (O'Connor et al., 2016), secondary school males (7.10 injuries per 1,000 hours) (Watson, 1996) and collegiate males (12.6 injuries per 1,000 hours) (O'Connor et al., 2017) all presented with overall injury incidence greater than senior club Ladies Gaelic football (Crowley et al., 2011). Injury incidences in males were greater during matches with a 3.4-8.4 greater match injury incidence in male adolescent and collegiate players (O'Connor et al., 2016; O'Connor et al., 2017). This may be as a result of higher intensity, an increase in competitiveness, desire to win, physicality and effort during matches (Roe et al., 2017; Wilson et al., 2007; O'Connor et al., 2016). Injury incidence in male Gaelic football increased as age and level increased, with a 2.6 times greater incidence in collegiate males (O'Connor et al., 2017), a 2.7 greater incidence in club level males (Wilson et al., 2007) and a 2.4 times greater incidence in elite males (Newell et al., 2006) compared to adolescent males. This increase in injury trend with an increase in age and level may be as a result of differences in intensity and physical demands (Murphy et al., 2012).

Table 2.5: Injury Incidence in Gaelic Football

Study	Participant Details	Sample Size (n)	No. of Injuries	Injury Rate		
				Per 1,000 hrs		
				O	T	C
Brown et al. (2013)	Ladies Senior Club	70	98	-	-	-
Crowley et al. (2011)	Ladies Senior Club	-	245	2.4	-	-
Watson (1996)*	Male Secondary School	150	199	7.10	3.11	17.60
O'Connor et al (2016)	Male Adolescent	-	-	4.89	3.01	9.26
O'Connor el al. (2017)	Male Collegiate	217	144	12.6	7.3	25.1
Crowley et al. (2011)	Male Senior Club	-	160	8.25	-	-
Wilson et al. (2007)	Male Senior Club	83	90	13.5	5.8	51.2
Murphy et al. (2012)	Male Senior Elite	851	1,014	-	4.05	61.86
Newell et al. (2006)	Male Senior Elite	511	471	11.8	5.5	64.0

O: Overall rate, **C**: competition rate, **T**: training rate, **Hrs**: hours,
- : not reported/available, * Data transposed from 10,000 hrs to 1,000

2.4.2 Injury Location

2.4.2.1 Injury Location in Adolescent Female Soccer

Lower limb injuries were predominant in adolescent female soccer, accounting for between 77.8% and 89% (Sentsomedi & Puckree, 2016; Le Gall et al., 2008; Söderman et al., 2001 a) of injuries. The knee, ankle and thigh were the most commonly reported locations of injury for adolescent female soccer players (Table 2.6).

Table 2.6: Injury location for Adolescent Female Soccer

Study	**n**	Location of Injury					
		1	%	2	%	3	%
Sentsomedi & Puckree (2016)	85	Knee	16.5%	Ankle	11.8%	Calf	9.4%
Clausen et al. (2014)	498	Knee	25%	Ankle	20%	Lower Leg	11%
Le Gall et al. (2008)	119	Ankle	24.6%	Thigh	22.3%	Knee	14.5%
Emery et al. (2005 b)	164	Ankle	-	Knee	-	Groin	-
Söderman et al. (2001 a)	153	Ankle	-	Thigh	-	Knee	-
Powell & Barber-Foss (1999)	6,642	Ankle/ Foot	33.5%	Hip/ Leg/ Thigh	25.8%	Knee	19.4%

*-: Not Reported; **n:** sample size

2.4.2.2 Injury Location in Gaelic Football

In club level Ladies Gaelic football 46.9-58% (Brown et al., 2013; Crowley et al., 2011) of injuries were to the lower extremities and 24-38.8% (Crowley et al., 2011; Brown et al., 2013) of injuries occurring in the upper extremities. Lower limb injuries accounted for the majority of injuries in male Gaelic football across all age groups with 74.7% of injuries occurring in the lower extremities in adolescent males (O'Connor et al., 2016), 71.1% in collegiate males (O'Connor et al., 2017), 71.1% in male senior club players (Wilson et al., 2007) and 69.0-76.0% in senior elite males (Murphy et al., 2012; Newell et al., 2006; Cromwell et al, 2000). The rate of lower extremity injury in Ladies Gaelic footballers is lower than that reported in male Gaelic football, but the rate of upper extremity injury in Ladies Gaelic football is greater than that in collegiate males (16.2%) (O'Connor et al., 2017), senior club males (21%) (Crowley et al., 2011) and elite males (11.1-23%) (Murphy et al., 2012; Cromwell et al., 2000).

Injuries to the knee, ankle and hamstring were commonly observed in club level Ladies Gaelic football, where knee injuries accounted for 10.2-18.8% (Brown et al., 2013; Crowley et al., 2011) of Ladies Gaelic football injuries and similarly ankle/foot injuries accounted for 11.4-19.4% (Crowley et al., 2011; Brown et al., 2013) of injuries. The hamstring, ankle and knee were the most commonly reported injury location for male Gaelic football, as seen in Table 2.7. Similar percentages of knee and ankle injuries were reported in both Ladies Gaelic football and male Gaelic football, where ankle injuries

accounting for 10.0-21.0% of Gaelic football injuries (Murphy et al., 2012; Cromwell et al., 2000) and knee injuries accounting for between 11.3-18.7% of male Gaelic football injuries (Murphy et al., 2012; O'Connor et al., 2016). Hamstring injuries were also commonly reported in male Gaelic football and have accounted for between 6.5-24.0% of injuries (Watson, 1996; Murphy et al., 2012), with hamstring injuries also reported in club level Ladies Gaelic football (11.4%) (Crowley et al., 2011) at a similar proportion of posterior thigh injuries in male club level male Gaelic football (12.2%) (Wilson et al., 2007). Upper extremity injuries have a lower injury occurrence in comparison to lower extremity, which may be surprising due to the significant amounts of upper body actions required in Gaelic football such as high catching, hand-passing, carrying the ball and tackling (Cromwell et al., 2000). Injuries to the fingers were commonly reported in club level Ladies Gaelic football with finger injuries accounted for 22.5% (Brown et al., 2013) and finger fractures accounted for 8.6% (Crowley et al., 2011) of injuries reported. Of the upper extremity injuries reported the shoulder had the highest level of occurrence (6.2% to 12.0%) observed in senior elite male players, which may be as a result of the permitted shoulder charge permitted in male football while tackling (Murphy et al., 2012; Cromwell et al., 2000).

Table 2.7: Gaelic football injury locations

Study	N	Participant Details	Location of Injury					
			1	%	2	%	3	%
Brown et al. (2013)	70	Ladies Senior Club	Fingers	22.5%	Ankle/ Foot	19.4%	Knee	10.2%
O'Connor et al. (2016)	-	Male Adolescents	Knee	18.7%	Hamstring	13.3%	Ankle	12.0%
O'Connor et al. (2017)	217	Male Collegiate	Hamstring	15.5%	Knee	14.1%	Ankle	11.3%
Murphy et al. (2012)	851	Male Senior Elite	Hamstring	24.0%	Knee	11.3%	Ankle	10.0%
Wilson et al. (2007)	83	Male Senior Club	Ankle	13.3%	Ant Thigh	12.2%	Post Thigh	12.2%
Newell et al. (2006)	511	Male Senior Elite	Hamstring	22.0%	Knee	13.0%	Ankle	11.0%
Cromwell et al. (2000)	107	Male Senior Elite	Ankle	21.0%	Hamstring	-	Knee	-

*- : Not Reported, **n:** sample size, **Ant**: Anterior, **Post**: Posterior

2.4.3 Nature of Injury

2.4.3.1 Nature of Injury in Adolescent Female Soccer

Muscular injuries (22.4-51%) (Powell & Barber-Foss, 1999; Sentsomedi & Puckree, 2016) and ligamentous injuries 1.2-38.7% (Sentsomedi & Puckree, 2016; Powell & Barber-Foss, 1999) were most frequently reported in adolescent female soccer players. Fractures (1.2-5.8%) (Sentsomedi & Puckree, 2016; Powell & Barber-Foss, 1999) and dislocations (0.3%) (Le Gall et al., 2008) were infrequently occurring within adolescent female soccer.

2.4.3.2 Nature of Injury in Gaelic Football

Muscle-related injuries were one of the most commonly reported nature of injuries reported in Gaelic football (Table 2.8), accounting for 35.5-40% (Brown et al., 2013; Crowley et al., 2011) of injuries in Ladies Gaelic football and 23.3-42.6% (Wilson et al., 2007; Crowley et al., 2011) in male Gaelic football. These high levels may be as a result of the common occurrence of hamstring and thigh injuries previously observed for Gaelic football. Ligament injuries were also commonly reported, accounting for between 13.2-32.0% (Murphy et al., 2012; Cromwell et al., 2000) of structures injured in male Gaelic football and 16.1% (Brown et al., 2011) of injuries in Ladies Gaelic football, similar to the muscular injuries and the dominant occurrence of hamstring injuries, the high levels of ligamentous injuries may be related to the high occurrence of ankle and knee injuries. Fractures were also more commonly reported in Ladies Gaelic football 12.9-41% (Brown et al., 2013; Crowley et al., 2011) compared to adolescent (4.0%) (O'Connor et al., 2016), collegiate (7.0%) (O'Connor et al., 2017), senior elite (4.4-5.0%) (Murphy et al., 2012; Cromwell et al., 2000) and senior club level (10.0-33%) (Wilson et al., 2007; Crowley et al., 2011) male Gaelic football.

Table 2.8: Nature of Gaelic Football Injuries

Author	Level	Nature of Injury (%)								
Gaelic Football		Muscle	Ligament	Tendon	Dislocation	Cartilage/ Meniscus	Muscle Strain	Ligament Sprain	Fracture	Bruise/ Contusion
Brown et al. (2013)	Ladies Senior Club	35.5%	16.1%	6.1%	-	3.5%	-	-	12.9%	13.0%
Crowley et al. (2011)	Ladies Senior Club	40%	-	-	-	-	-	-	41%	-
O'Connor et al. (2016)	Male Adolescents	-	-	10.7%	1.3%	5.3%	30.7%	22.7%	4.0%	8.0%
O'Connor et al. (2017)	Male Collegiate	-	-	6.3%	1.4%	2.8%	32.4%	27.5%	7.0%	16.9%
Crowley et al. (2011)	Male Senior Club	52%	-	-	-	-	-	-	33.3%	-
Wilson et al. (2007)	Male Senior Club	-	-	-	-	-	23.3%	17.8%	10.0%	27.8%
Murphy et al. (2012)	Male Senior Elite	42.6%	13.2%	9.2%	-	-	-	-	4.4%	-
Newell et al. (2006)	Male Senior Elite	-	-	-	-	-	42.0%	26.0%	-	17.0%
Cromwell et al. (2000)	Male Senior Elite	33.0%	32.0%	16.0%	-	3.0%	-	-	5.0%	6.0%

* **-** : Not Reported

2.4.4 Injury Severity

2.4.4.1 Injury Severity in Adolescent Female Soccer

Most injuries in female adolescent soccer have been classified as minor or grade II (34-72.5%) (Söderman et al., 2001 a; Powell & Barber-Foss, 1999) which lasted <7 or <8 days (Table 2.9). In contrast, Söderman et al. (2001 a) found moderate injuries (7-30 days) were the most prevalent, representing over half of the injuries (52%) recorded. Major injuries (> 21 days or > 30days) were the least reported injuries accounting for 12.1-14% of injuries reported (Powell & Barber-Foss, 1999; Le Gall et al, (2008); Söderman et al., 2001 a). With the classification system used by Emery et al. (2005 b) grade I (0-1 day) injuries that resulted in minimal time loss or no time loss, accounted for 35.9%, which was also one of the most frequently reported severity, highlighting the importance of using a broad injury definition to ensure the reporting of all types of injuries which may have been missed with the commonly used time-loss only definitions observed (Emery et al., 2005 b). The burden associated with soccer injuries found that 3.9% of all soccer injuries required surgical intervention, 84.1% of which were required for knee injuries (Powell & Barber-Foss, 1999). Over eight-years of soccer exposure, an average of 1,142 days were lost per season as a result of injury, with each player injured for an average of 46 days per year and the mean absence from the sport was 18 days (Le Gall et al., 2008).

Table 2.9: Severity of Adolescent Female Soccer Injuries

	Severity Classification	Severity Definition	Occurrence
Le Gall et al. (2008)	Minor	<7 days	51.9%
	Moderate	7-30 days	35.7%
	Major	>30 days	12.4%
Emery et al. (2005 b)	Grade I	0-1 day	35.9%
	Grade II	2-7 days	35.9%
	Grade III	8-14 days	7.7%
	Grade IV	>14 days	20.5%
Söderman et al. (2001 a)	Minor	<7 days	34%
	Moderate	7-30 days	52%
	Major	>30 days	14%
Powell & Barber-Foss (1999)	Minor	<8 days	72.5%
	Moderate	8-21 days	15.4%
	Major	>21 days	12.1%

2.4.4.2 Injury Severity in Gaelic Football

No previous research in Ladies Gaelic football has examined injury severity. The most frequent injury severity classification system reported in Gaelic football was the three-tiered system with mild/ minor injuries resulting in <7 days lost, moderate injuries resulting in 8-21 days lost and severe injuries resulting in >21 days lost from participation (O'Connor et al., 2016; O'Connor et al., 2017; Newell et al., 2006; Wilson et al., 2007). Injury severity in male Gaelic football is displayed in Table 2.10, where minor/ mild injuries accounted for between 10-41.7% of injury severities (Cromwell et al., 2000; O'Connor et al., 2016), 20.8-56% reported were moderate injuries (O'Connor et al., 2016; Newell et al., 2006) and severe injuries represented 20-41.6% of injuries (Cromwell et al., 2000; Murphy et al., 2012). Similar to adolescent female soccer where minor injuries were predominant (Le Gall et al., 2008; Powell & Barber-Foss, 1999), minor injuries were also predominant in adolescent male Gaelic football (O'Connor et al., 2016). For male collegiate players, sprains had the highest injury burden with 130.5 days absent per 1,000 hours while strains and fractures had 113.8 and 68.7 days absent per 1,000 hours respectively (O'Connor et al., 2017). In male senior elite Gaelic footballers, the average days lost from participation for fractures (returned to play in the same season) resulted in a loss of 38.7 days, tendon injuries accounted for 32.4 days lost, ligament injuries (excluding anterior cruciate ligament (ACL) injuries) accounted for 25.3 days lost and muscular injuries resulted in an average of 19.7 days lost (Murphy et al., 2012).

Table 2.10: Severity of Injuries in Gaelic Football

	Level	Severity Classification	Severity Definition	Occurrence
O'Connor et al. (2016)	Male Adolescents	Minor	<7 days	41.7%
		Moderate	8-21 days	20.8%
		Severe	>21 days	37.5%
O'Connor et al. (2017)	Male Collegiate	Minor	<7 days	34.8%
		Moderate	8-21 days	29.8%
		Severe	>21 days	35.5%
Murphy et al. (2012)	Male Senior Elite	Mild	1-7 days	13.2%
		Moderate	8-27 days	45.2%
		Severe	>28 days	41.6%
Wilson et al. (2007)	Male Senior Club	Mild	1-7 days	4.35 per 1,000h
		Moderate	8-21 days	6.45 per 1,000h
		Severe	>21 days	2.55 per 1,000h
Newell et al. (2006)	Male Senior Elite	Minor	<1 week	10%
		Moderate	1-3 weeks	56%
		Severe	>3 weeks	34%
Cromwell et al.(2000)	Male Senior Elite	Minor	1-7 days	38%
		Moderate	8-27 days	42%
		Major	>28 days	20%

2.4.5 Mechanism of Injury

2.4.5.1 Mechanism of Injury in Adolescent Female Soccer

Limited research is available for the mechanisms of injury in adolescent female soccer. The most common mechanisms of injury for adolescent female soccer were; collision (12.9%), running (11.8%) and tackling (9.4%) (Sentsomedi & Puckree, 2016), with a similar percentage of contact injuries reported in both male and female adolescent soccer (46.15%) (Emery et al., 2005 b).

2.4.5.2 Mechanism of Injury in Gaelic Football

Mechanisms of injury have not been described for Ladies Gaelic football to date, and this may be as a result of the retrospective data collection methods used in the current research (Brown et al., 2013; Crowley et al., 2011). Multiple mechanisms of injury have been reported for male Gaelic football players (Table 2.11), with non-contact injuries more commonly observed than contact injuries across different player levels; adolescent males (64.0% vs 36.0%) (O'Connor et al., 2016), collegiate males (52.1% vs 47.9%) (O'Connor et al., 2017) and for male senior elite players (60-67.8% vs 32.2-40%) (Newell et al., 2006; Murphy et al., 2012). Sprinting (14.4-26.8%) (Wilson et al., 2007; Murphy et al., 2012) and being tackled (12.2-17.8%) (O'Connor et al., 2016; Wilson et al., 2007) were the most

commonly reported mechanisms of injury. Turning and twisting injuries were also reported mechanisms of injury, with twisting and turning accounting for 12.0-19.0% of senior elite male injuries (Murphy et al., 2012; Cromwell et al., 2000) and 13.3% of senior club injuries (Wilson et al., 2007). The reporting of non-specific mechanisms of injury within the male adolescent (24.3%) (O'Connor et al., 2016) and male collegiate players (9.9%) (O'Connor et al., 2017) may be associated with the levels of overuse injuries reported (26.7% & 21.1% respectively) (O'Connor et al., 2016; O'Connor et al., 2017). Although there is a high level of kicking involved in Gaelic football kicking mechanism of injury were low with ~4% of male senior club players (Wilson et al., 2007), 9.5% of adolescent males (O'Connor et al., 2016) and 7.8% of collegiate males reporting this mechanism of injury (O'Connor et al., 2017).

Table 2.11: Mechanisms of Injury in Gaelic Football

Study	Participant Details	Mechanism of Injury					
		1	%	2	%	3	%
O'Connor et al. (2016)	Adolescent Male	Sprinting	*25.7*	Non-Specific	*24.3*	Being Tackled	*12.2*
O'Connor et al. (2017)	Collegiate Male	Sprinting	*24.8*	Being Tackled	*13.5*	Non-Specific	*9.9*
Wilson et al. (2007)	Senior Club Male	Being Tackled	*17.8*	Sprinting	*14.4*	Turning	*13.3*
Murphy et al. (2012)	Elite Senior Male	Sprinting	*26.8*	Turning	*12.0*	Landing	*7.1*
Cromwell et al. (2000)	Elite Senior Male	Collision	*22.0*	Twist/ Turn	*19.0*	Running	*13.0*

* **-**: Not Reported

2.4.6 Injury Onset

2.4.6.1 Injury Onset in Adolescent Female Soccer

Acute injuries in female adolescent soccer players (40.6-86.4%) (Clausen et al., 2014; Le Gall et al., 2008) have a higher occurrence than overuse injuries (13.4-34.0%) (Le Gall et al., 2008; Söderman et al., 2001 a). Injury onset has also been described as new, recurrent or persistent. Recurrent injury rates in female soccer have varied from 4.4%-41% (Le Gall et al., 2008; Söderman et al., 2001 a). In addition, 56% and 40% of ankle and muscle injuries respectively were recurrent (Söderman et al., 2001 a).

2.4.6.2 Injury Onset in Gaelic Football

Overuse injuries accounted for 24.9% of injuries reported in senior club Ladies Gaelic football (Crowley et al., 2011), indicating acute injuries were predominant. However, caution must be taken with this analysis as data was collected using injury claim forms, which may be biased towards more acute and severe injuries. Acute injury onsets were predominant in Gaelic football with 73.3% of injuries noted in adolescent males (O'Connor et al., 2016) and 78.9% for collegiate males (O'Connor et al., 2017). In elite senior males, 6% of injuries recorded were of insidious onset, without a specific timing to one individual match or training session (Murphy et al., 2012). Injuries reported as new, recurrent or persistent are seen in Table 2.12 below where in the recurrent category, there is an early recurrence and late recurrence. Early recurrence involves the recurrence of an injury in less than two months since the original onset, and late recurrence is the recurrence of an injury between two and twelve months (Fuller et al., 2007 c). The new injury onsets were between 52.7-76.6% (O'Connor et al., 2016; O'Connor et al., 2017) of injuries and recurrent injuries explained between 10.6-35% (O'Connor et al., 2017; Cromwell et al., 2000) of injuries observed. Early recurrence of injuries ranged between 6.9-14.9% (Murphy et al., 2012; O'Connor et al., 2016) and 2.1-16.2% of injuries (O'Connor et al., 2017; O'Connor et al., 2016) were late recurrent.

The onset types have not been reported in Ladies Gaelic football to date. In addition to the high levels of recurrent injuries reported among adolescent male players a persistent injury rate of 16.2% was also observed (O'Connor et al., 2016). This rate of persistent injuries raises concerns regarding the effectiveness of rehabilitation being completed prior to returning to participation or may indicate that players are continuing to play while injured (O'Connor et al., 2016). High levels of persistent injuries were also observed for collegiate male footballers (12.8%), however, the levels of recurrent injuries were lower than that of adolescent male footballers, (10.6% vs 31.1 respectively) (O'Connor et al., 2016; O'Connor et al., 2017). Persistent injuries may also be contributed to by players continuing to participate and play while injured where 46% of players continued their participation despite suffering an injury and from those who continued to play, 93% of those reported restrictions and reductions in their performance ability (Cromwell et al., 2000).

Table 2.12: Onset Types of Gaelic Football Injuries

		New	Recurrent	Early Recurrent	Late Recurrent	Persistent
O'Connor et al. (2016)	Adolescent Male	52.7%	31.1%	14.9%	16.2%	16.2%
O'Connor et al. (2017)	Collegiate Male	76.6%	10.6%	8.5%	2.1%	12.8%
Murphy et al. (2012)	Elite Senior Male	74.7%	23.0%	6.9%	10.5%	-
Cromwell et al. (2000)	Elite Senior Male	65.0%	35.0%	-	-	-

* **-** : Not Reported

2.5 Injury Risk Factors

Skeletally immature athletes, specifically adolescents, are at particular risk for sports-related injuries, due to the physical and physiological processes occurring during periods of growth (Caine et al., 2014). Differences are observed in the injuries sustained by children and adolescents when compared to adults. Risk factors that make young athletes vulnerable to injury include; growth plate vulnerability, differences between biological and chronological age, the adolescent growth spurt, differential growth and underdeveloped co-ordination and skills development (Caine et al., 2014). With an increase in participation and training loads endured at earlier ages and throughout the years of growth, there is a concern that the load tolerance limits of the physis may be surpassed by the increased mechanical stresses observed in sports (Caine et al., 2006). Contact sports in particular or repetitive physical loading required in other sports such as distance running, or gymnastics are of primary concern (Caine et al., 2006). Injuries or the fear of injury accounts for up to 8% of adolescents dropping out of sporting activities annually (Grimmer et al., 2000; Emery et al., 2007; Emery et al., 2005 a). Injuries in athletes can result in compromised performance, financial burdens and potential long-term health implications (Windt & Gabbett, 2017).

Risk factors for injury in sport are any contributing factors that may increase or alter a participant's risk of injury and are commonly classified as either intrinsic or extrinsic (Caine & Goodwin, 2016). Intrinsic risk factors are athlete-dependent and extrinsic risk factors are environment-dependent (Frisch et al., 2009 a; Bahr & Holme, 2003). Intrinsic risk factors are exclusive to the participant and are individual, biological and psychological characteristics that can predispose to injury, e.g. age, gender and previous injury (Caine & Goodwin, 2016; Dvorak et al., 2000). Extrinsic risk factors impact the athlete while participating in sports such as; sports context, protective equipment, playing rules, playing surface and coaching education and training methods (Caine & Goodwin, 2016; Frisch et al., 2009 a). Risk factors can be further sub-classified as potentially modifiable and non-modifiable (Figure 2.3) (Habelt et al., 2011). Modifiable risk factors are those that have the potential to be changed by injury prevention strategies to decrease injury rates (Emery, 2003). Non-modifiable risk factors, however, cannot be altered and can affect the association between modifiable risk factors and injury (Emery, 2003; Caine & Goodwin, 2016).

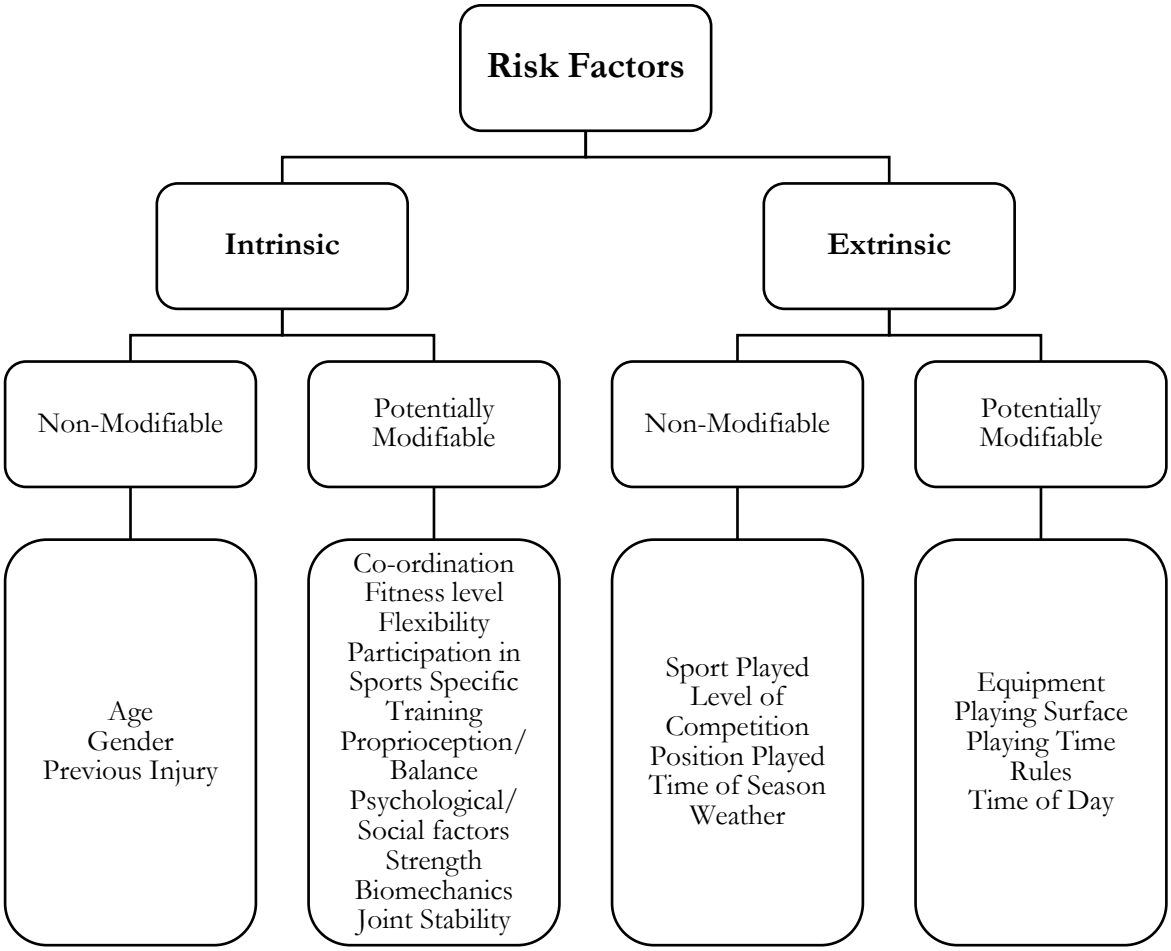

Figure 2.3: Potential Risk Factors for Sports-Related Injury (Habelt et al., 2011 & Emery, 2003)

The presence of intrinsic and extrinsic risk factors makes an athlete susceptible to injury, however, the presence of risk factors does not result in an injury, it is the combination and interaction of risk factors that make an athlete vulnerable to injury in certain situations (Bahr & Krosshaug, 2005). The process of injury causation is described in the Dynamic Model of Etiology in Sports Injury by Meeuwisse et al. (2007). The dynamic model of etiology is recursive in nature, which takes into consideration that participation in the activity and the associated physiological adaptations to training may modify the impact of certain risk factors (Meeuwisse et al., 2007; Windt & Gabbett, 2017). The model also allows for the fact that injuries may result in a variety of outcomes including recovery and return to participation with a modified injury risk as well as incomplete recovery and a complete cessation of participation (Meeuwisse et al., 2007; Windt & Gabbett, 2017).

Windt & Gabbett (2017) developed the Workload-Injury Aetiology Model (Figure 2.4), which is a progression of the Bannister Fitness-Fatigue Model and takes into consideration the effects of athlete workloads and the positive and negative impact it can have on injury risk (Windt & Gabbett. 2017; Roe et al., 2017). Training and competition loads are neither intrinsic or extrinsic risk factors but have been described as a 'vehicle' in the injury risk process when athletes have been exposed to an extrinsic risk factor and potential inciting events (Windt & Gabbett, 2017). Workloads do not directly contribute to injury; however, they contribute to an athlete's injury risk through exposure to the potentially injurious situations (Windt & Gabbett, 2017). The workload-injury aetiology model incorporates the effects of workload on injury risk factors using the recursive nature of Meeuwisse et al.'s (2007) dynamic model of etiology. The main progression of this model to the dynamic model of etiology includes; incorporation of the application of workloads, identification that adaptations occur as a result of each completed workload, athletic adaptations may affect modifiable intrinsic risk factors and subsequent workloads will be completed with altered levels of injury risk and the considerations of injury rehabilitation and return-to-play phases within the process (Windt & Gabbett, 2017).

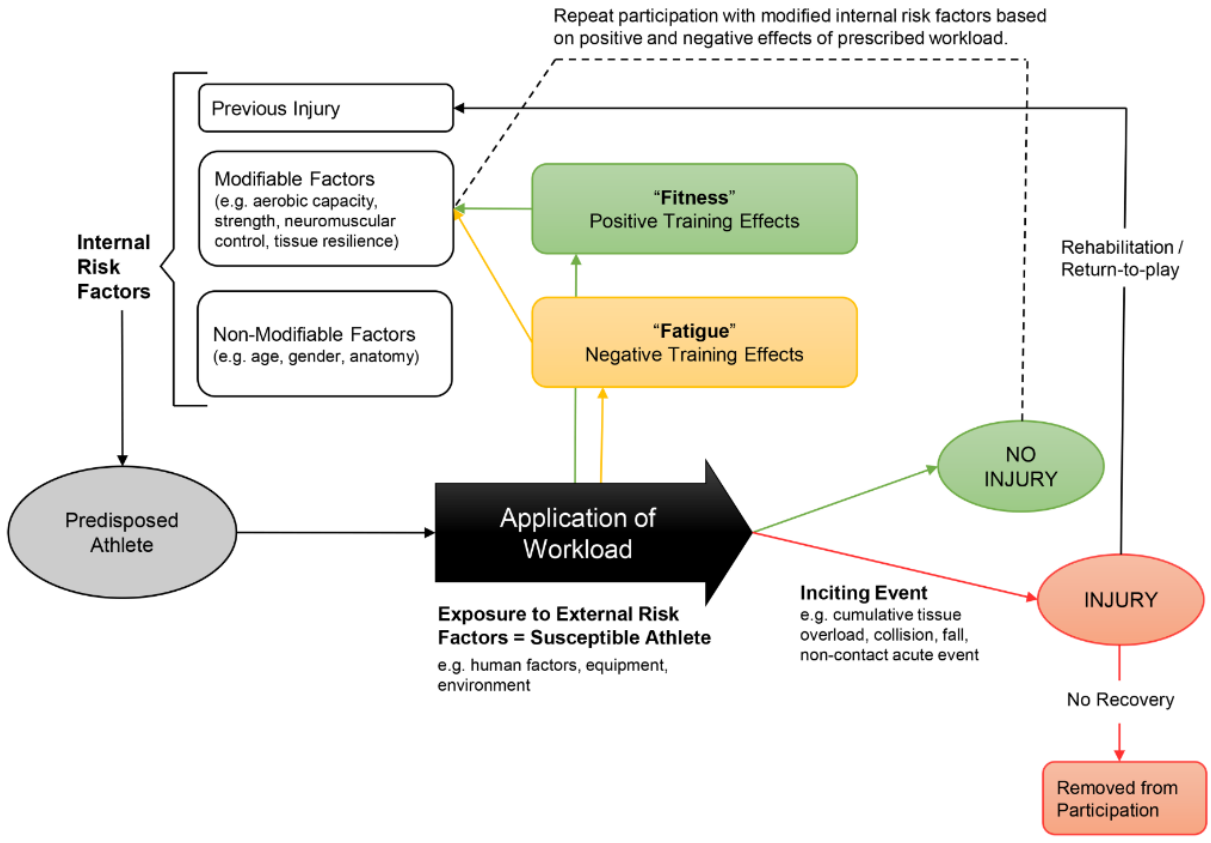

Figure 2.4: The Workload-Injury Aetiology Model (Windt & Gabbett, 2017)

The Operational Framework for Managing Injury risk proposed by Roe et al. (2017) is a six-step framework aimed at guiding healthcare and medical professionals in the management of injury risk (Figure 2.5). The framework is divided into three sub-sections; awareness of injury trends and risk factors (stage 1 & 2), assessing the demands of the sport and the capabilities of the player (stage 3 & 4) and monitoring the players response to interventions (stage 5 & 6) (Roe et al., 2017). The aim of stage 1 is to identify when, where and how athletes sustain injuries, similar to step 1 and 2 of both the sequence of prevention and TRIPP models (van Mechelen et al., 1987; Finch, 2006) and the aim of stage 2 is to establish specific risk factors that increase or decrease the risk of injury such as acute spikes in training load or previous injury (Roe et al., 2017). Stage 3 sport demand looks to identify what demands a player should be prepared for while participating and thus stage 4 looks at analysing the individual player for characteristics of injury risk and/or success as identified in stage 1 and 2 (Roe et al., 2017). Physical characteristics that are highly desirable and related with elite levels of participation may also be identified and used to assess readiness and opportunities to improve performance (Roe et al., 2017). Finally, as part of the monitoring player response sub-section, stage 5 athlete management aims to clarify the favourable short-term and long-term outcomes to an intervention with stage 6 athlete monitoring assessing how the player responds to the intervention over time (Roe et al., 2017). Some potential methods identified to assist in player monitoring particularly in Gaelic football include; load management, GPS running distances, acute: chronic workloads, knee flexor strength, heart rate recovery, player wellness and session RPE scores (Roe et al., 2017).

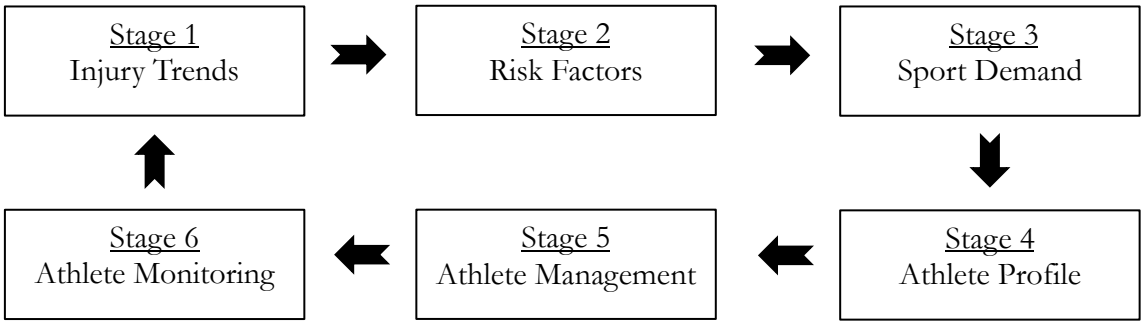

Figure 2.5: Operational Framework for Managing Injury Risk (Roe et al., 2017)

2.5.1 Intrinsic Non-Modifiable Risk Factors

2.5.1.1 Age

Age is a non-modifiable risk factor and as a participant continues to age the risk of injury also increases (Emery, 2003). Differences are observed in the injuries sustained by children and adolescents when compared to adults. Risk factors that make young athletes vulnerable to injury include; growth plate vulnerability, differences between biological and chronological age, the adolescent growth spurt, differential growth and underdeveloped co-ordination and skills development (Caine et al., 2014). Increased injury risk as older athletes age may be as a result of decreased muscle elasticity and the increase in fibrosis within connective tissues, reduction in muscular strength, size and endurance as a result of skeletal muscle fibres reducing in size and reductions in recovery abilities from previous injury as a result of satellite cell circulation reduction with age and the presence of increased fibrous connective tissue (Martini et al., 2012). Of the sports and recreation-related injuries reported in the United States, 65% of all injuries occurred in 5-24-year-olds, with 5-14-year-olds having the greatest injury rate at 76.6 per 1,000 persons (Sheu et al., 2016). Adolescents over 13 years of age have shown a greater risk of sports-related injury than younger children, with 10-14-year-olds sustaining a significantly greater ($p= 0.010$) level of injuries when compared to 5-9-year-olds (Emery, 2003; Lykissas et al., 2013). Male adolescent rugby players had a significantly greater ($p= 0.002$) injury risk with an increase in age (Archbold et al., 2015). Older adolescents aged 13-17 years old also required a significantly greater ($p< 0.001$) number of surgical interventions than younger adolescents and children aged 5-12 years old (Stracciolini et al., 2013). The increase in injury occurrence as adolescents and children age may be as a result of the increased relative risk as training and games typically increase in intensity and duration with age (Stracciolini et al., 2013). However, varying results have been observed for female adolescent soccer players. Le Gall et al. (2008), found a greater injury incidence in the younger U-15 players than in the U-16, U-17, U-18 and U-19 players, compared to Söderman et al. (2001 a) who found a greater injury incidence in 16-16.9-year old than younger 15-15.9 and 14-14.9-year olds and older 17-19.2-year olds.

In addition to chronological age described above, biological age may also contribute to injury risk in adolescent athletes. Biological maturation relates to the development of a child and adolescent towards reaching the mature state (Lloyd et al., 2014). Adolescents with the same chronological age may vary significantly in biological maturity levels,

including early maturation and late maturation (Figure 2.6) (Caine et al., 2014; Lloyd et al., 2014). The level of maturity or the magnitude of change, the timing of maturity or the onset of change and the tempo of maturity or the rate of change can all contribute to varying levels of biological maturity (Lloyd et al., 2014). Differences in biological age may create unbalanced competition among adolescents since competitions are categorised by chronological age (Caine et al., 2014). Particularly for male adolescents, structural, functional and performance benefits associated with early-maturation in sports and activities requiring size, strength or power have been highlighted, along with the altered level of injury risk potentially affected by the unbalanced competition in early and late maturing adolescents (Caine & Maffulli, 2005).

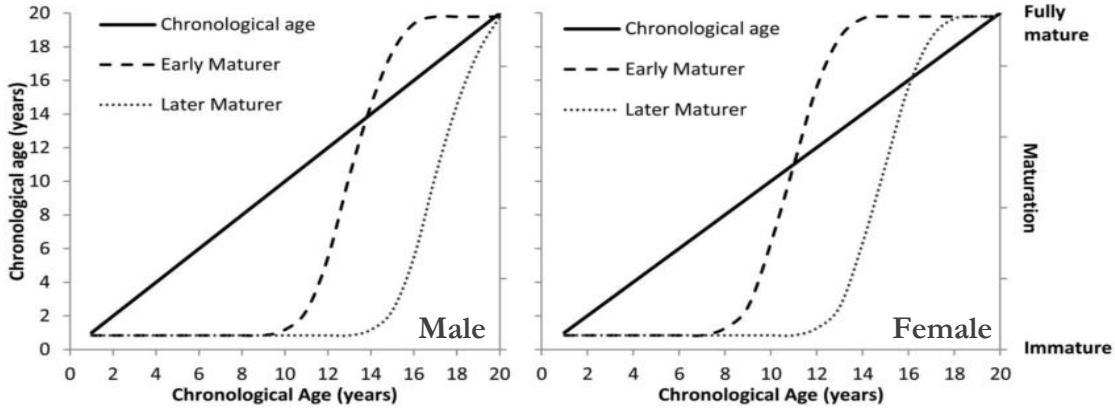

Figure 2.6: Chronological Age and Biological Development in Male and Females (Lloyd et al., 2014)

2.5.1.2 Gender

Conflicting research is available regarding gender differences in injury incidence which may be further affected by the sport in question and the location and type of injury (Stracciolini et al., 2014). Differing results may be as a result of data collection methods and injury definitions. In all sports related injuries reported, younger adolescents (11-13 years old) showed no significant gender differences in injury incidence ($p>0.05$), in comparison to older adolescents (14-17 years old) where males had a significantly higher sports-related injury incidence ($p= 0.004$) than their female counterparts (Schneider et al., 2012). When isolating individual sports in younger adolescents, girls had a greater injury incidence than boys in; basketball (9.151 vs. 8.867 per 1,000 AEs), cross-country running (10.864 vs. 7.999 per 1,000 AEs), soccer (7.964 vs. 7.445 per 1,000 AEs) and wrestling (10.256 vs. 9.954 per 1,000 AEs), in comparison to volleyball (5.167 vs. 4.638) where boys

had the greater injury incidence (Beachy & Rauh, 2014). In comparison high school boys soccer (2.81 vs 2.35 per 1,000 AEs) and basketball (2.32 vs 1.28 per 1,000 AEs) reported greater injury incidence compared to their female counterparts (Knowles et al., 2006 a) but females reported higher injury incidence in track (1.18 vs 1.06 per 1,000 AEs) (Knowles et al., 2006 a) and track and field (0.99 vs 0.72 per 1,000 AEs) (Pierpoint et al., 2016) compared to males. Contrasting results observed may be a result of different injury definitions used (e.g. set minimum time loss required or treatment required) and differences in data collection methods (e.g. prospective vs retrospective). Like the injury risk differences observed in differing sports, injury types and injury locations may also vary. In children and adolescents (5-17 years old) the injury risk for the different types of injuries was observed by Stracciolini et al. (2014). Fractures were noted to be more prominent in males, accounting for 19.5% of all injuries in comparison to 8.2% in females, whereas patellofemoral pain syndrome was more prominent in females accounting for 14.3% of all injuries in comparison to 4% of injuries in males (Stracciolini et al., 2014). Proposed reasons for the differences in injury risk in adolescent boys and girls include boys tend to be more aggressive during participation have a greater body mass, participate in more contact sports generally and have a greater level of contact compared to girls. In addition, hormonal and anatomical differences exist between genders, increased joint laxity is evident in girls, and differences in motor control also exist, particularly poorer motor control at the knee in females (Habelt et al., 2011; Caine & Goodwin, 2016).

2.5.1.3 Previous Injury

The most commonly accepted risk factor for injury is a previous history of injury (Frisch et al., 2009 a; DiFiori et al., 2014). This could potentially be due to functional instability or proprioceptive deficits, muscular strength imbalances or impairments, mechanical instability or persistent ligament laxity, reduced muscular flexibility and joint range of motion, and localised scar tissue that occur following injury (Murphy et al., 2003). Post muscular strain, the resultant scar tissue is believed to lack functionality compared to the original uninjured tissue which may be a contributing factor to the risk of re-injury (Hrysomallis, 2013).

In Australian football, a previous injury to a lower limb muscle group was found to be the most significant risk factor associated with a future injury in the same muscle group (Orchard, 2001). Similarly, within elite male soccer players, a history of a previous lower

extremity muscular injury increased the risk of quadriceps and calf muscular injuries by between 68% and 91% (Hägglund et al., 2013). Defective movement compensations or altered biomechanics after the initial injury still present when the player has returned to participation could lead to the increased risk at a different muscular site (Hägglund et al., 2013). For elite adult and youth athletes of both genders, an increased risk of injury (p= 0.039) was observed in athletes who had sustained a serious injury, lasting longer than three weeks, in the previous season (Jacobsson et al., 2013). Within youth elite athletes, males who sustained a severe injury in the previous year had four times greater risk of injury than females with no previous history of injury (Jacobsson et al., 2013). Similarly, elite male soccer players who sustained an injury in the previous season had an approximately three times greater risk of sustaining an injury in the current season, with the number of injuries sustained in the previous season increasing this relative risk (Hägglund et al., 2006). Recurrent injuries were also observed within adolescent male Gaelic footballers and hurlers with 14.9% and 8.3% of injuries classified as early recurrent injuries and 16.2% and 8.3% of classified as late recurrent injuries (O'Connor et al., 2016).

2.5.2 Intrinsic Potentially Modifiable Risk Factors

2.5.2.1 Strength

In adolescents participating in sports on a recreational or competitive basis, strength asymmetries between sides have been proposed as a risk factor for injury (Sannicandro et al., 2014). Reductions in muscular strength or imbalances post initial injury can increase the injury risk as joint stability, biomechanics and the proficiency to safely participate in activities may be compromised (Fulton et al., 2014). Strength deficits between injured and non-injured limbs and between muscle groups have been reported as one factor leading to an increased risk of re-injury in hamstring strains, ACL ruptures and Achilles tendon ruptures (Fulton et al., 2014). One in four female high school athletes presented with anterior-posterior thigh muscle imbalances and leg asymmetries, potentially increasing their risk of sustaining an ACL injury (Pappas et al., 2016). In female soccer players, lower concentric hamstring-quadriceps ratios significantly increased (OR= 0.93) a player's risk of sustaining a traumatic leg injury (Söderman et al., 2001 b). Asymmetries in hamstring eccentric strength have also been identified as a significant (OR= 3.88) risk factor for hamstring strains in professional male soccer players, along with previous hamstring strains (OR= 0.15) and asymmetries in functional leg lengths (OR= 3.80) (Fousekis et al., 2011). Hamstring: quadriceps ratios were also found to be significantly

lower ($p < 0.05$) in college level male Gaelic footballers with a previous hamstring injury history, with decreases of approximately 10% observed in previously injured limb compared to uninjured limbs (O'Sullivan et al., 2009). Similar patterns have been observed in the upper extremity with adolescent handball players with a muscular strength imbalance, between shoulder internal and external rotators, 2.5 times at greater risk for sustaining a shoulder injury than players without an imbalance present (Edouard et al., 2013).

In sports requiring single limb preference, such as a preferred leg in soccer primarily used for kicking, muscular imbalances between limbs may lead to an increased inclination for injury in that preferred limb (Hägglund et al., 2013). The differential use of muscles specifically during kicking is observed where the non-preferred or stance leg uses the knee flexors to assist with joint stabilisation, support the players body weight and resist the reaction of torque produced by the kicking leg during the kicking motion, in comparison to the preferred kicking leg which aims to minimise concentric knee flexion to allow forceful knee extension to kick the ball (Rahnama et al., 2005). This single leg preference may also occur in Gaelic football where kicking is a major component of passing, travelling with the ball in the form of a solo and scoring. Significant knee flexor concentric muscular strength imbalance was observed between the preferred and non-preferred in elite and sub-elite soccer players (119 ± 22 vs 126 ± 24 Nm) (Rahnama et al., 2005). In elite male Gaelic footballers significantly more injuries occurred to the dominant/kicking leg (59%) than the non-dominant/ stance leg (Newell et al., 2006). Similarly, in senior college level male Gaelic footballers 68% of hamstring injuries reported were to the dominant/ kicking leg (O'Sullivan et al., 2009).

Other research has found no differences between dominant and non-dominant legs have also been reported (Murphy et al. 2003). No significant differences in muscular injury type, location and length of injury were found in elite male soccer players (Svensson et al., 2016). In soccer players of all levels and ages, no significant difference was observed between non-contact ACL injuries in dominant (51.72%) and non-dominant (48.28%) limbs (Brophy et al., 2010). In youth female soccer players, no significant differences between acute knee injuries to the dominant (46%) and non-dominant (48%) limbs were observed (Hägglund & Waldén, 2016). However, in female soccer players of all age and playing levels non-contact ACL injuries to the non-dominant leg (52-67.74%) were significantly higher ($p = 0.011$; $p < 0.002$) when compared to the dominant leg (29-32.26%) (Hägglund & Waldén, 2016; Brophy et al., 2010). The greater incidence of ACL

injuries in the non-dominant limb of youth female soccer players include; high levels of muscular strength and kinematic imbalances between dominant and non-dominant limbs and significant differences in neuromuscular control levels between limbs which may contribute to a greater exposure to high-risk single leg loading patterns during kicking and cutting movements on the non-dominant limb (Hägglund & Waldén, 2016).

2.5.2.2 Proprioception, Balance & Co-Ordination

Proprioception is a complex neuromuscular process defined as one's ability to combine and interpret sensory signals received from various mechanoreceptors to determine body position and movement in space and significantly contributes to balance control (Han et al., 2015; Schiftan et al., 2015). Proprioceptive control involves the effectiveness of the bodies stabilising reflexes to control and maintain vertical stability and is an important contributor to joint stability and injury prevention (Riva et al., 2016). With improvements in proprioceptive control an increase in movement control, effective control of jumping and landing and a reduction in the mechanical stress placed on the lower extremities have been observed (Riva et al., 2016). Ankle proprioception is one of the main factors contributing to balance in sporting activities as the ankle-foot complex is primarily the main part of the body in contact with the ground (Han et al., 2015). Balance is a person's ability to maintain the body over its base of support and deficits in balance are associated with injury risks specifically in the lower extremity (Knight et al., 2016; Caine & Goodwin, 2016). Ankle proprioception, and as a result balance, can be affected positively or negatively by sports-specific training, injury and fatigue (Han et al., 2015). Significantly greater risks for sustaining an ankle sprain in adolescent high school basketball players were found with poor balance ($p= 0.0002$) and high postural sway ($p= 0.001$) (McGuine, 2000). Dynamic balance measured using the Star Excursion Balance Test, found high school and collegiate American football players, with lower anterior reach distances, were at a significantly ($p< 0.001$) greater risk of sustaining an injury (Gribble et al., 2016). Potential changes (limb lengths, body mass and moments of inertia) in coordination and movement patterns during the adolescent growth spurt may be due to altered or excessive force generation while strength and coordination skills are being developed (DiFiori et al., 2014). Postural co-ordination is the coordination of multiple body parts that are required for functionally maintaining an upright stance (Paterno et al., 2015). The loss or reduction of joint positional awareness may give rise to impaired postural coordination as a result of altered muscle recruitment patterns during dynamic movements, deficits in

joint stability and a decrease in the ability to control standard movement (Paterno et al., 2015).

2.5.2.3 Physical Conditioning

Poor physical conditioning can increase a player's risk of a sports-related injury (Willems et al., 2005). Aerobic fitness levels have previously been suggested as modifiable risk factors for injury in adults (Watson et al., 2017 a). Fatigue and the physiological and biomechanical adaptations of aerobic fitness levels are proposed as mechanisms that increase injury risk (Watson et al., 2017 a). Fatigue has been described as a transient reduction in the capacity to perform physical actions (Enoka & Duchateau, 2008) and may be a result of metabolite accumulation within muscle fibres, inadequate motor commands generated in the motor cortex and the lack of global mechanisms responsible for fatigue (Enoka & Duchateau, 2008). With lower levels of aerobic fitness, fatigue occurs earlier which may alter muscle recruitment patterns leading to altered or compensatory force distribution on the surrounding musculoskeletal structures increasing an athlete's predisposition to injury (Watson et al., 2017 b). Fatigue can impact biological function, altering the normal capacity of the various biological systems to function at the optimal and desired levels (Cortes et al., 2014). Fatigue contributes to alterations in central and peripheral neuromuscular processes which can result in the reduction of movement performance (Cortes et al., 2014). Altered muscle activation patterns, fluctuations in isometric force production, distorted limb motion dynamics, and postural tremors can also occur (Cortes et al., 2014). Fatigued athletes during side-stepping and cutting movements, commonly associated with field sports, were found to have significantly affected ground reaction forces and knee kinematics when compared to their non-fatigued state (Cortes et al., 2014; Fuller et al., 2017). Specifically, significant ($p < 0.05$) reductions in anterior-posterior, medio-lateral and vertical ground reaction forces were observed as well as ankle dorsiflexion angle, hip abduction angle and moment, and knee abduction ankle (Cortes et al., 2014). As a result of the variations in ground reaction forces and joint kinematics, specifically around the knee, the overall result of fatigue has been proposed as a reduction or loss of coordination during movement, which may increase the risk for sustaining a knee ligament injury (Cortes et al., 2014).

Twenty-three percent of senior elite male (Murphy et al., 2012), 48.5% of collegiate male (O'Connor et al., 2017) and 36% of adolescent male (O'Connor et al., 2016) sustained an injury in the final quarter of matches. The main reason suggested for the high incidence

of injury within the final quarter of matches is fatigue and slower reaction times, in conjunction with a proposed increase in intensity and concentration in the final stages of matches required to win while in a fatigued state (Wilson et al., 2007, Newell et al., 2006; O'Connor et al., 2016). Poorer physical conditioning levels lead to an earlier onset of fatigue and a reduction in the protective capabilities of the musculature on the surrounding ligamentous and capsular structures (Willems et al., 2005). A significant reduction in cardiorespiratory endurance ($p= 0.022$) and running speeds ($p= 0.019$) was observed in male college students who sustained an ankle injury (Willems et al., 2005). Preseason maximal aerobic capacity (VO_{2max}) has also been identified as a significant predictor ($p= 0.046$) of the number of injuries sustained by an adolescent female soccer player, with a ~5% reduction in injury risk observed for every 1-mL/kg/min increase in preseason VO_{2max} levels (Watson et al., 2017 a).

2.5.2.4 Flexibility & Joint Stability

Flexibility around a joint is dependent upon the geometry of the articular surfaces and the laxity of muscles, tendons, ligaments and joint capsules (Murphy et al., 2003). Conflicting findings have been reported in the relationship between poor flexibility and an increase in injury risk overall. Positive relationships between poor flexibility and an increased injury risk in quadriceps injuries in professional male soccer players (OR= 10.70) (Fousekis et al., 2011), in female collegiate athletes a 15% imbalance in hip extension flexibilty resulted in a significant ($p< 0.001$ right vs left) increase in lower extremity injury (Knapik et al., 1991) and in professional male soccer players significantly lower hamstring (88° vs 95°) and quadriceps (121° vs 129°) flexibility were found in players who sustained an injury (Witvrouw et al., 2003). A significantly lower ($p= 0.002$) hamstring flexibility level was observed in Gaelic footballers with a previous history of a hamstring injury when compared to uninjured players (Lowther et al., 2012). No relationships between poor flexibility and injury risk have been found in hamstrings of professional soccer players (Fousekis et al., 2011) in hamstrings ($p= 0.496$) of male amateur soccer player (van Doormaal et al., 2017), in hamstrings ($p= 0.076$) community-level Australian footballers (Gabbe et al., 2004) and in hamstring of elite Australian footballers ($p= 0.746$) (Gabbe et al., 2005). During periods of growth in adolescence the increase in muscle-tendon tightness and associated related loss of flexibility has been suggested as a risk factor for injury, however in the majority of adolescent sports, flexibility was not found to be associated with injury (Caine & Goodwin, 2016; DiFiori et al., 2014; Emery, 2003).

Generalised joint hypermobility, an excessive range of motion in the majority of synovial joints, may also influence joint stability and consequently injury risk (Blokland et al., 2017). Generalised joint laxity within adult female soccer players significantly increased (OR= 3.10; p= 0.02) the risk of sustaining a traumatic leg injury (Söderman et al., 2001 b). Similarly, in elite female soccer players classified with generalised joint hypermobility, although not statistically significant an increased risk of injury by 1.10 times was observed in comparison to players not meeting the criteria (Blokland et al., 2017). Joint laxity and hypermobility are common among adolescents and in general, are associated with an increased incidence of musculoskeletal injuries specifically; ankle sprains, shoulder instability, ACL injuries and osteoarthritis in the hand (Wolf et al., 2011). Excessive anterior translation laxity in the knee has been suggested as a risk factor for non-contact ACL injuries (Mouton et al., 2015). In healthy contralateral knees of ACL-injured patients, the presence of joint laxity above the normal threshold was observed in 40% of patients, with a participant displaying above normal ranges of joint laxity 3.18 times more likely to be in the ACL-injured group than a healthy control group (Mouton et al., 2015).

2.5.2.5 Movement Patterns

Inadequate or deficient mechanics during high-level functional skills have been related to an increased risk of future sports-related injury (Fulton et al., 2014). Biomechanical risk factor for injury can be classified into kinetics and kinematics, where kinematics investigates motion and kinetics referred to the forces that cause or change motion (McGinnis, 2013; Hall et al., 2013). Repetitive vertical loading rates and impact forces are kinetic risk factors contributing to the risk of injury particularly during running (Hall et al., 2013). Kinetic and kinematic factors such as joint stiffness and joint orientation effect the risk of injury. Joint stiffness is the relationship between deformation and force application, and through optimal muscle activation patterns a reduction in joint loading may be achieved by priming the joint for impact and altering the joint stiffness (Hall et al., 2013). Injury occurs when the tissue is question is exposed to a force or motion beyond its threshold and its mechanical properties are violated (Kumar, 2001). Abnormal joint alignment of the hip, knee and ankle joint may also lead to decreased function or aberrant biomechanics, which may result in an increased risk of lower extremity injury (Bowerman et al., 2015). The differences in lower extremity biomechanics in male and female team sports athletes during landing and cutting movements may also contribute to the increased risk of ACL injury in females (Orishimo et al., 2014). Aberrant hip biomechanics has been associated with altered injury risk at the knee (Powers, 2010). In

patellofemoral pain syndrome, aberrant biomechanics and kinematics at the hip joint may impact the lateral forces acting on the patella contributing to its mal-tracking (Powers, 2010). In adult female runners increases in ankle dorsiflexion range of motion (knee extended p= 0.02, knee flexed p= 0.01), standing arch index (p= 0.01) and greater vertical loads while running (p= 0.04) were all significantly associated with the plantar fasciitis injury group compared to the control (Pohl et al., 2009). Similarly, in adult runners with Achilles tendinopathies, a significant decrease (p= 0.011) in knee flexion range of motion between the heel strike and mid-stance phase of running was observed in the injured runners compared to healthy controls (Azevedo et al., 2009). In addition, significant differences in muscle activity during running were found in the tibialis anterior pre-heel strike (p= 0.003), the rectus femoris post-heel strike (p= 0.000) and the gluteus medius post-heel strike in the runners with Achilles tendinopathy (Azevedo et al., 2009). Therefore, aberrant movement patterns may result in an increase in a players' risk of injury, particularly in the lower extremity during running.

2.5.2.6 Psychological & Social Factors

Varying psychological and personality traits may influence the level of sports injury risk, including; sensation seeking, stress-coping strategies, competition or performance anxiety, behavioural traits and coping strategies regarding life events (Steffen et al., 2009). Athletes with trait anxiety, state anxiety, type A personality behaviours and stress predisposition have a higher risk of injury (Ivarsson et al., 2013). In addition, fear of re-injury post-injury is associated with altered muscle recruitment patterns and neuromuscular deficits, which can increase future risk of re-injury (Hsu et al., 2016).

An athlete's ability to tolerate or process stressful situations and the success of their stress response will directly affect the athlete's cognitive and physiological responses potentially altering the risk of injury (Williams & Andersen, 1998; Ivarsson et al., 2014). Stress-related risk factors have been sub-classified into three categories; coping abilities (e.g. acceptance), personality traits (e.g. a predisposition to anxiety) and previous history and experience with stressors (e.g. previous negative life events or stresses or daily hassle) (Williams & Andersen, 1998; Ivarsson et al., 2014). In addition to the cognitive stresses, behavioural and physiological stress responses are also potential risk factors for injury (Figure 2.7) (Appaneal & Perna, 2014; Johnson & Ivarsson, 2017). Female youth soccer players with higher levels of life stress were found to be at significantly greater risk (p= 0.001) for sustaining a new soccer injury (Steffen et al., 2009). Similarly, female adolescent

soccer players with significant baseline levels of life stress and changes in their normal daily levels of life stress were significantly found to be predictors of injury ($p< 0.01$) (Ivarsson et al., 2014). Levels of life stress have been associated with behavioural, emotional and cognitive responses which may contribute to increased psychological fatigue and potentially related to increases in injury risk (Ivarsson et al., 2014). In addition, during periods of high academic stress, injuries were three times greater in male collegiate starting American football players ($p= 0.002$) (Mann et al., 2016).

In relation to over-use or chronic injuries, additional psycho-physiological and sociocultural factors, such as inadequate recovery and mental fatigue, have been identified as factors that may alter the risk of injury (Johnson & Ivarsson, 2017). Socioeconomic norms and subcultural values or norms may also have an impact on the risk of sustaining an injury such as low tolerance of pain complaints, and the expectations required to succeed in sports for example not complaining about pain or minor injuries and playing while injured (Johnson & Ivarsson, 2017; Emery, 2003; Kelishadi et al., 2016). In Canadian adolescents, a greater sport or recreational activity injury risk was associated with higher socioeconomic status levels (Simpson et al., 2005). Similarly, in Iranian students (6-18 years old) the risk of sustaining a sports-related injury was greater in the high (OR= 1.96) and middle (OR= 1.44) socioeconomic class than low socioeconomic classed students (Kelishadi et al., 2016).

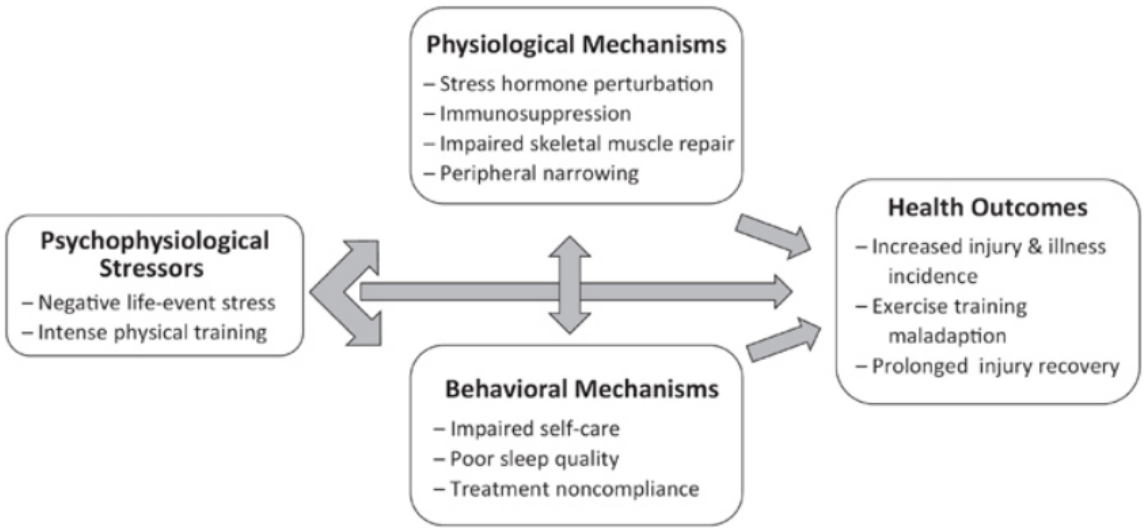

Figure 2.7: The Biopsychosocial Model of Stress and Athletic Injury (Appaneal & Perna, 2014)

2.5.3 Extrinsic Non-Modifiable Risk Factors

2.5.3.1 Type of Sport

The risk of injury in adolescents is greater in sports involving contact and jumping (Rosendahl & Strouse, 2016). Injury incidence for female adolescent team sports was greater than individual sports generally with team sports varying from 4.1 injuries per 1,000 athletic exposures (AEs) in rugby (Collins et al., 2008) and 6.66 injuries per 1,000 AEs in soccer (Barber Foss et al., 2014) to 0.99 injuries per 1,000 AEs in track and field (Pierpoint et al., 2016) and 0.94 injuries per 1,000 AEs in tennis (Beachy & Rauh, 2014). In high school sports, non-contact sports had lower injury incidence overall with golf, swimming, tennis, volleyball and diving (0.00, 0.68, 0.94, 1.31 and 1.96 injuries per 1,000 AEs respectively) having lower injury incidence than contact sports such as soccer, judo and wrestling (3.19, 3.88 6.41 injuries per 1,000 AEs respectively) (Beachy & Rauh, 2014). Contact is a commonly reported mechanism of injury within sports where player contact (58%) and other forms of contact including with equipment (20%) and has accounted for up to 78% of game injuries in collegiate athletes (Hootman et al., 2007). These high levels of contact injuries may be directly a result of the playing rules of the game where physical contact is required such as wrestling or rugby that is unpredictable in nature and unavoidable (Hootman et al., 2007). The use of protective equipment and stricter game rules and regulations have been suggested as potential methods for reducing the occurrence of contact injuries (Hootman et al., 2007).

In Gaelic football, injuries are more predominant in matches (O'Connor et al., 2016; O'Connor et al., 2017; Murphy et al., 2012). The proposed reasons for the greater match injury incidence in Gaelic football is based on the higher intensity or participation during matches (Roe et al., 2017; Wilson et al., 2007; O'Connor et al., 2016). In addition to higher intensity levels an increase in competitiveness, desire to win, physicality and effort have also been reported (Wilson et al., 2007; O'Connor et al., 2016). Lower incidences of training injuries have been accredited to manager supervision, more controlled settings and less hectic environments during a training session in comparison to matches (Newell et al., 2006).

2.5.3.2 Position Played

In adolescent male Gaelic football, midfielders were the most commonly injured players (33.9% of all injuries sustained) (O'Connor et al., 2016). Goalkeepers only accounted for 16% of injuries with the remainder of injuries occurring in backs (25.7%) and forwards (24.4%) (O'Connor et al., 2016). Similarly, in elite female soccer player midfielders had the highest injury incidence of 42.4 injuries per 1,000 match hours followed by defensive players (23.5 per 1,000 match hours), attacking players (22.7 per 1,000 match hours), wingers (15.2 per 1,000 match hours) and goalkeepers accounting for the lowest incidence of 12.1 injuries per 1,000 match hours (Tegnander et al., 2008). The higher proportion of injuries within midfielders may be due to the higher level of physicality and intensity maintained while playing in the midfield position, where players are required to cover greater distances while both attacking and defending with repeated bouts of jumping and contesting for high balls (O'Connor et al., 2016).

2.5.3.3 Time of Season

For child and adolescent soccer players (9-14 years old), 33% of all injuries occurred during pre-season and 29% during the first two weeks of competition participation and declined as the season continued with only 17% of injuries occurring in the final weeks (Malina et al., 2006). In adolescent male Gaelic football, 63.8% of injuries occurred in the preseason and similar results were observed for adolescent hurlers over the same period (67.4%) (O'Connor et al., 2016). Pre-season and early season injuries may be more common due to the greater training loads and more match play while players may have poorer or inadequate levels of physical conditioning (O'Connor et al., 2016; Wilson et al., 2007) with a gradual decline in injury incidence as player conditioning improves throughout the season and typically a change in training to focus on match skills from conditioning.

2.5.4 Extrinsic Potentially Modifiable Risk Factors

2.5.4.1 Equipment

Suitably fitted individual equipment is vital for all sports to provide adequate protection and to prevent injury (Dalton, 1992). Improper fitting or poor maintenance of equipment and failure to use equipment appropriate for specific sports may also contribute to injury (DiFiori et al., 2014). It is commonly seen in youth sports that equipment that is inferior

quality or ill-fitting may be used which may predispose an athlete to injury (Dalton, 1992). Boot design features including; sole shape, stud shape, stud length and stud patterns or arrangement, may increase the levels of boot to surface torsion and risk of injury as a result (O'Connor & James, 2013). In American football, the type of boots worn by players were found to have an impact on the risk of ACL injury due to the differences in the shoe to surface torsional resistance depending on the cleat or stud placements and types (Lambson et al., 1996; Murphy et al., 2003). The use of mouth guards is mandatory in both men's and ladies' Gaelic football for both juvenile and adult grades. Previous research into the use of protective equipment in adolescent male Gaelic footballers found that 73.3% of players did not wear any additional protective equipment outside of the mandatory mouth guards (O'Connor et al., 2016) and additionally in collegiate level male Gaelic football only 9.7% of players wore additional protective equipment outside of the mandatory mouth guards (O'Connor et al., 2017). Previous research in Gaelic football has proposed the benefits of protective equipment as a method for injury prevention as protective padding has been suggested to reduce the rate of contusions and fractures (O'Connor et al., 2017; O'Connor et al., 2016; Wilson et al., 2007).

2.5.4.2 Playing Surface

Ground hardness or the effect the surface has on absorbing impact energy and the traction on a specific playing surface are the two main surface factors related to injury risk (Petrass & Twomey, 2013). In Australian footballers, dry field conditions were shown to have an increased risk of quadriceps muscle strain and non-contact ACL injuries, with higher frictional and torsional resistance in shoe-surface traction, found (Hrysomallis, 2013). In adolescent and adult male rugby union players, very hard playing surfaces were associated with a 50% higher injury risk when compared to firm playing surfaces (Chalmers et al., 2012). In severely injured soccer players 21% of those reported the playing surface as being poor due uneven or excessively slippery surfaces, however, 45.2% of severely injured players reported the playing surface as being good (Chomiak et al., 2000). Twenty nine percent of injured elite male Gaelic footballers reported that pitch conditions contributed to their injury, with 43% reporting dry or hard pitches, 39% wet or soft pitches and 18% reported uneven surfaces (Cromwell et al., 2000).

Differences in playing surface were also suggested as potential risk factors for injury, with artificial surfaces for field sports being one of the suspected risk factors for injury. In collegiate soccer, no significant differences were observed for training and match injury

incidence for both male (p= 0.21 and p= 0.46) and female players (p= 0.46 and p= 0.16) on third-generation artificial pitches compared to grass (Fuller et al., 2007 a; Fuller et al., 2007 b). However, during a three-year period of collegiate soccer, a significantly lower (p= 0.016) total injury incidence was observed on the newer artificial FieldTurf (46.6%) compared to natural grass (53.4%) (Meyers, 2010). A significantly lower minor injury incidence (p= 0.001), substantial injury incidence (p= 0.020) and severe injury incidence (p= 0.049) were all observed for the artificial FieldTurf compared to the natural grass (Meyers, 2010). A greater surface consistency on the artificial FieldTurf irrelevant of precipitation and temperature, allowing for normal game place and impact, has been suggested as one of the main contributing factors to the lower injury incidence compared to varying natural grass surfaces (Meyers, 2010).

2.5.4.3 Playing Time and Training Loads

The potential increase in the contribution of overscheduling in youth sports is of growing concern and may be contributing to fatigue and overuse related injuries (Caine & Goodwin, 2016). The training schedule for adolescent athletes should be specific to the individual and consider associated growth characteristics, skeletal maturity and anatomical malalignments (Dalton, 1992). Training volume and intensity have previously been correlated with overuse injury risks (DiFiori et al., 2014). Participation for both club and school may also pose a further risk for injury as it may lead to further increased exposure and higher training and competition volume (Post et al., 2017), which may be seen in adolescent Gaelic games where players may participate at club, school and county level simultaneously. Sports participation of children, adolescents and young adults (4-24 years old) for more than 230 hours per year showed a significantly greater (OR= 2.17; p< 0.001) risk of injury, with participation levels of 80-132 hours a year having a significantly lower (OR= 0.49; p< 0.001) level of injury risk (Kemler et al., 2015). Similarly, young athletes who sustained an injury reported participating in more PA overall (19.6 6 9.2 vs 17.6 6 8.9 hours per week; p< 0.001) and greater amounts of organised sports activity (11.2 6 2.6 vs 9.1 6 6.3 hours per week; p< 0.01) compared to uninjured young athletes (Jayanthi et al., 2015). Adult female soccer players who had a higher soccer participation rates also reported a significantly greater risk (OR= 1.56; p= 0.04) of sustaining a traumatic leg injury than those with lower participation rates (Söderman et al., 2001 b). The concern surrounding overuse injury concern has also been associated with year-round training

scheduling in a single sport and simultaneous involvement in multiple teams (Di Fiori et al., 2014).

Sports specialisation, as with any PA, may carry potential risks such as; overuse injuries, burnout and social isolation (Hall et al., 2015). Adolescent students who were moderately (Hazard Ratio= 1.51; p= 0.03) or highly (Hazard Ratio= 1.85; p= 0.02) specialised in sports were at a significantly greater risk of sustaining a lower extremity injury (McGuine et al., 2017). In fact, adolescent female athletes had a greater relative risk in specialised single sports athletes for overuse knee injuries than those in multiple sports participation (Hall et al., 2017). In specialised single sports female adolescent athletes, a 1.5-time increase in relative risk of patella femoral pain syndrome diagnosis was observed (p=0.038) as well as a 4-time increase in relative risk of Sinding Larsen Johansson syndrome or patella tendinopathy diagnosis (p= 0.005) (Hall et al., 2015). Sports specialisation may result in an increase in injury risk because of the higher training volumes adapted by specialised athletes (Jayanthi et al., 2013).

With increases in training loads in adolescents, it is important to consider training load monitoring, an attempt to avoid injury and stress fracture occurrence, stagnancy in performance and drop out from participation, through early identification (Pind & Mäestu, 2017). Training loads can be analysed as both relative workloads, which looks at the change in training (e.g. percentage increase from week to week or week to month ratios), and absolute workloads which is the sum of the internal or external loads (e.g. Monday to Sundays) or the accumulation (e.g. sum of workloads over previous week) (Drew & Finch, 2016). Adequate workloads are needed for an athlete to enhance and perfect their physical and performance qualities (Malone et al., 2018). Periods of training load intensification, acute changes in training loads, accumulated training loads and the training-injury prevention paradox, all have varying effects on the association between training loads and injury occurrence (Jones et al., 2017). Periods of training load intensification are commonly observed during the preseason, increased periods of competition and injured players returning to participation (Jones et al., 2017). Elite collision sports athletes were 50-80% more likely to sustain a pre-season injury with pre-season training loads of 3,000-5,000 AU (Gabbett, 2010). In contrast, low training loads during the pre-season in Australian football were associated with 1.9 times greater relative risk of injury when compared to medium and high training loads, where the high and medium training loads also completed a greater proportion of training sessions and

matches throughout the season (Murray et al., 2017). Although typically spikes in training loads have been associated with injury risk, Malone et al., (2017 a) found that elite Gaelic football players participating in an in-season training camp did not sustain an injury throughout the duration of the training camp. However, the lack of injuries sustained may have been as a result of the monitoring and overall reduction in maximal velocity and lower limb power capabilities recorded which resulted in an overall reduction in the intensity in the remaining training sessions (Malone et al., 2017 a). Acute changes in training loads are associated with week to week changes in training loads (Jones et al., 2017). In professional rugby union players, absolute week-to-week changes in training loads of 1,069 AU or approximately 3.5 hours of average intensity (RPE of 5) training was associated with approximately 60% increase in injury risk for the following week (Cross et al., 2016). Additionally, in amateur male hurlers, in comparison to small weekly changes in training loads large absolute differences (≥ 1,000 AU) in senior amateur hurlers increased the odds of sustaining an injury both during the pre-season (OR= 5.58) and in-season (OR= 4.98) (Malone et al., 2018). Previous week to current week changes in elite Australian footballers' training loads of > 1,250 AU had higher in-season injury occurrence (OR= 2.58, p= 0.002) in comparison to the reference group of < 250 AU changes (Rogalski et al., 2013). Similar to both senior amateur hurlers (Malone et al., 2018) and elite Australian footballers (Rogalski et al., 2013), elite male Gaelic footballers who reported previous week to current week changes in training loads of > 1,000 AU were at greater risk of injury compared to the reference group (< 120 AU) during both the pre-season (OR= 2.58) and late in-season (OR= 2.22) (Malone et al., 2017 b).

Accumulated training loads look at the prolonged accumulation of training loads and are of importance as they highlight the consequences of coaches' ability to manage players' training and competition schedules such as the periodisation of starting players and the duration of the off-season or training breaks, to sustain performance and reduce injuries (Jones et al., 2017). Elite Gaelic footballers with high 1 weekly workloads (≥ 2,770 AU) were also associated with significantly higher risk of injury (OR= 1.63) compared to low training load reference group (≤ 1,250) (Malone et al., 2017 b). Playing experience in elite Gaelic football and higher aerobic capacity also contributed to the injury risk when exposed to spikes in training loads, where players with 1 years' experience were at risk of injury (OR= 2.22) compared to 2-3 years' experience (OR= 0.20) or 4-6 years' experience (OR= 0.24) who were able to tolerate the spikes in load, and where players with poorer aerobic fitness levels had a higher injury risk compared to high aerobic fitness levels (OR=

1.50-2.50) (Malone et al., 2017 b). In elite Australian football, players with 1 weekly training loads in excess of 1,750 AU were at significantly greater risk (OR= 2.44, p= 0.007) of injury compared to the reference group (< 1,250 AU) and furthermore players with 2 weekly loads greater than 4,000 AU were at significantly higher risk of injury (OR= 4.74, p= 0.033) compared to the reference group (< 2,000 AU) (Rogalski et al., 2013). Similarly, Bowen et al. (2017) also found high 1 weekly training loads (474-648 AU) were related to the greatest significant relative injury risk for overall injuries (RR= 1.65, p= 0.032) and also non-contact injuries (RR= 2.20, p= 0.007) in elite youth soccer. Excessive cumulative fatigue which is adaptations without sufficient recovery may result in a reduction in the amount of stress that tissues can tolerate and beyond their threshold of load is an increase in injury risk (Cross et al., 2016). The training-injury prevention paradox looks at the association between moderate training loads and injury risk reduction (Jones et al., 2017). A U-shaped relationship between training loads and injury is described, where low training loads fail to provide adequate stimulus for training adaptations to occur as a resistance to injury and high training loads create physical and metal fatigue in an athlete where their musculoskeletal systems are unable to completely tolerate the forces encountered while participating in activities (Jones et al., 2017; Quarrie et al., 2017; Gabbett, 2016). This U-shaped relationship between 4 weeks cumulative training loads and injury risk has been demonstrated in professional male rugby union players, where a likely beneficial reduction (OR= 0.55) in injury risk were observed for high-intermediate (5,932-8,651 AU) training loads and a potentially harmful effect (OR= 1.39) was observed in high training loads (> 8,651 AU) when compared to the reference group of low training loads (< 3,684 AU) (OR= 1.00) (Cross et al., 2016). Moderate weekly training loads (1,400-1,900 AU) were previously shown to have a protective effect against injury in senior amateur hurlers during both the pre-season (OR= 0.44) and in-season (OR= 0.59) (Malone et al., 2018). Similarly, in adolescent male Gaelic players a training load threshold was identified at ≥ 1,200 training units per week, where a 51.7% increased risk of injury was observed in players reporting training units greater than the threshold in comparison to those reporting less than the threshold (RR= 1.52) (Miley et al., 2017). In addition, elite collision sports athletes who exceeded the training load threshold were found to be up to 70 times more likely to report a non-contact soft-tissue injury compared to athletes who did not exceed the threshold (Gabbett et al., 2010). Moderate workloads in conjunction with moderate-high changes in acute: chronic workload ratios also appeared to possess a protective effect for male elite Gaelic football

players (Malone et al., 2017 b). Lower training load levels during the pre-season in Australian football although not statistically significant ($p= 0.17$) had an observed trend towards higher injury rates than either medium or high training loads (Murray et al., 2017).

2.6 Injury Prevention

The TRIPP framework, previously discussed in Section 2.3 (Figure 2.2), in addition to the implementation of injury surveillance, the establishing of injury aetiology and mechanisms and development of preventative measures, aims to incorporate practical consideration and knowledge into the uptake and compliance of preventative methods (Finch, 2006). This compliance may be a significant factor in the negative or insignificant effects observed from previously conducted field-based research in which injury preventions strategies were implemented (Finch, 2006). Stage 5 of the TRIPP model highlighted the critical importance of understanding the motivations and effective ways to work alongside different sports and their current safety and injury cultures in order to improve safety (Finch, 2006). Although Finch (2006) emphasised the importance of programme implementation and effectiveness, only 1% of sports injury prevention research focuses on the implementation and effectiveness (Donaldson et al., 2018). Numerous disparities between injury prevention research and implementation have hindered previous injury prevention efforts including; the efficacy-to-effectiveness gap, the research-to-practice gap and the injury-prevention-to-safety-promotion gap (Hanson et al., 2014). These disparities arise from the conflicting approaches that researchers, policymakers, medical professional and the community, including coaches, take to the all the challenges (scientific, practical and social) posed by the related complexity of injury and injury prevention (Hanson et al., 2014). In an attempt to maximise the effectiveness of injury prevention strategies, they should be tailored to the playing experience, level and age of coaches and players to account for different baseline levels of injury risk knowledge and injury prevention beliefs (McKay et al., 2014).

In an attempt to further progress the research into IPP adherence, Owoeye et al. (2018) described a proposed framework for the development of effective adherence strategies (Figure 2.8) which was adapted from the van Mechelen sequence of prevention. The initial step of the effective adherence strategies framework involves the identification and description of the magnitude of the adherence or non-adherence issues and rates in previously conducted trials, which may also include analysing any modifications made by the users of the IPP (Owoeye et al., 2018). Following the initial step, the second step aims to identify any predictors of adherence or non-adherence which may involve considering programme related factors such as intervention components, psychosocial factors and the determinants of behaviour change (e.g. intention and self-efficacy), social factors like

socioeconomic status and organisational factors like club structures (Owoeye et al., 2018). In order to identify the full determinants of adherence or non-adherence, they should be examined across multiple levels from the individual users i.e. coaches or healthcare professionals to the wider sports environment in administrators (Owoeye et al., 2018). The identification of both barriers and facilitators of adherence throughout the multiple levels should also be considered to gather a true understanding of the full extent of the issue (Owoeye et al., 2018). Once the extent and determinants of adherence or non-adherence have been identified this information in conjunction with current literature may be used to design and implement strategies attempting to improve the adherence rates to current and future IPP (Owoeye et al., 2018). These strategies may be designed and formulated by targeting changes in users' behaviours, expanding organisational support, reducing the duration of IPP interventions, the provision of user incentives and removing or reducing the previously identified barriers to adherence (Owoeye et al., 2018). The final step in the proposed framework involves the evaluation of the effectiveness of the adherence strategy implemented in step three which is of utmost importance as it may be used to guide stakeholders in areas of success to assist with the direction of future resources to promote behavioural changes towards IPP (Owoeye et al., 2018). This final evaluation step may be conducted by gathering feedback by using focus groups, interviews and direct observations or open and close-ended questionnaires (Owoeye et al., 2018).

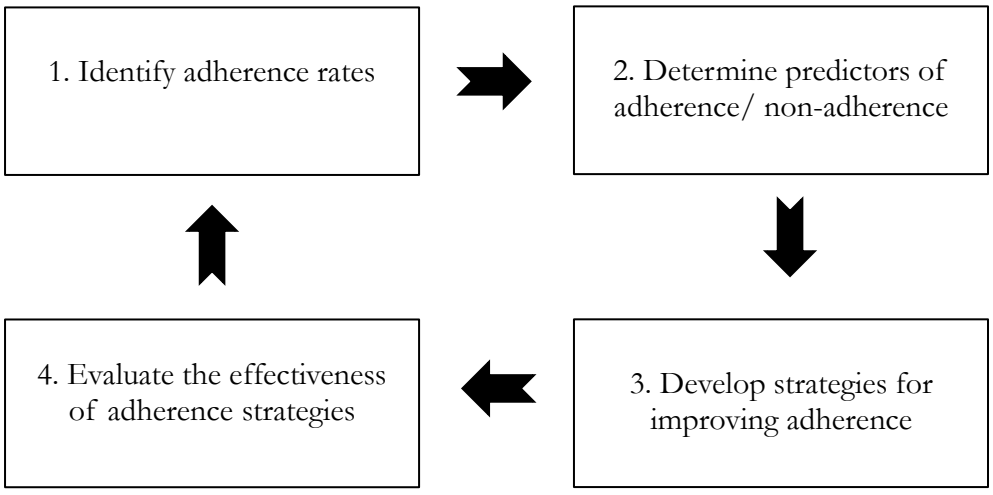

Figure 2.8: Proposed research framework for the development of effective adherence strategies (Owoeye et al., 2018)

The Theory of Planned Behaviour (TPB) (Figure 2.9) is one of the most commonly cited models for prediction of human social behaviour and a validated social-cognitive model of human behaviour that has been suggested as suitable method of identifying beliefs and how human action is guided (Ajzen, 2011; de Leeuw et al., 2015; Francis et al., 2004). The TPB proposes that voluntary unforced human behaviour is a function of intention to perform a behaviour and perceived behavioural control (Sniehotta et al., 2014). There are three main assumptions with the theory of planned behaviour; the first is the effect of attitude and subjective norm on behaviour is suggested to be full and the effect of perceived behavioural control on behaviour is partial and facilitated by intention (Sniehotta et al., 2014). The second is the effects that behavioural, normative and control beliefs have on intention and behaviour are hypothesised to be facilitated through attitude, subjective norm and perceived behavioural control. Finally, the effects of all additional biological, social, environmental, economic, medical and cultural influences are theorised to be mediated by the theory of planned behaviour (Sniehotta et al., 2014).

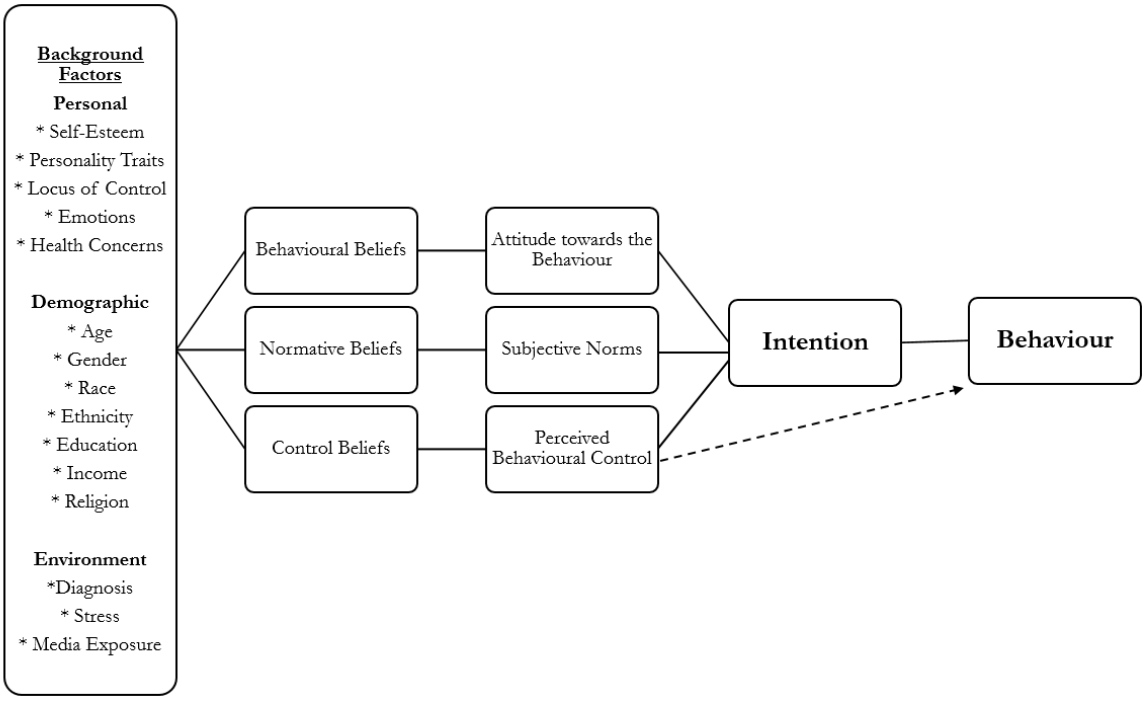

Figure 2.9: Ajzen's (1991) Theory of Planned Behaviour (Maio et al., 2007)

2.6.1 Injury Prevention in Gaelic Games

Injury prevention programmes (IPP) have been developed to reduce injuries in Gaelic footballers including the GAA 15 and the Activate GAA warm up. The GAA 15, which is a neuromuscular IPP standardised warm-up specific to Gaelic games (Schlingermann et al., 2017; O'Malley et al., 2017), and the Activate GAA warm-up, is another Gaelic games' specific dynamic warm-up designed to reduce the incidence of ACL and lower limb injuries, to be completed prior to training and games and includes the use of a ball (Sports Institute Northern Ireland, 2017). The GAA 15 is a 15-minute warm-up programme that includes elements of strength, core stability, balance, plyometric, agility exercises and movement control, specifically, there are running, activation, sports specific balance, jumping, hamstrings and potentiation activities (O'Malley et al., 2017). The focus of the GAA 15 is to develop neuromuscular control both unilaterally and bilaterally, develop muscular strength and muscle activation, and to develop and improve jump-landing mechanics and technique (O'Malley et al., 2017). The Activate GAA warm-up includes three phases; the first is running, cutting and landing mechanics, the second strength, plyometric and balance and the third and final includes agility and power (Sports Institute Northern Ireland, 2017). Phases one and three are recommended before games and all phases are recommended before training sessions.

Current research into the benefits or effects of GAA specific IPP strategies is limited. O'Malley et al. (2017), investigated the effects of the GAA 15 on neuromuscular outcomes in collegiate Gaelic footballers and hurlers and was completed at the start of training twice a week for the duration of eight weeks. Clinical and statistically significant increases for dynamic balance and jump-landing techniques were found for the players participating in the GAA 15 compared to the control players who conducted their usual training or warm-up (O'Malley et al., 2017). Increases in Y-balance test composite scores were 3.85% and 4.34% greater for right and left legs compared to the control and landing error score systems were significantly greater ($p < 0.001$) in the GAA 15 intervention group compared to the control group post-intervention (O'Malley et al., 2017). Using a modified version of the GAA 15, which included warm-up, dynamic stretching, activation using mini-bands and sports specific components, Schlingermann et al. (2017) looked at the effects the GAA 15 had on low extremity injury in collegiate Gaelic footballers and hurlers. The GAA 15 was completed for the full duration of the collegiate season prior to every training session or game in the intervention group and the control group utilised

a dynamic warm-up without the inclusion of the mini-band activation, low level plyometric, and full body dynamic stretches (Schlingermann et al., 2017). The intervention group had almost a three times lower injury rate (2.62 injuries per 1,000 hrs) when compared to the control group (7.62 injuries per 1,000 hrs) and additionally there was an overall injury incidence reduction of 66% and training injury incidence reduction of 80% in the intervention group (Schlingermann et al., 2017). A 41% reduction of hamstring injuries, 68% of knee injuries and 61% of non-contact injuries were observed in the intervention (GAA 15) players compared to the control (Schlingermann et al., 2017). Provisional results of the effects of the GAA 15 on injuries in adolescent hurlers, found a lower injury incidence in the intervention group (9.16 injuries per 1,000 hrs) compared to the control group (16.51 injuries per 1,000 hrs), and an overall reduction in lower extremity injuries by 45% and match injuries by 29% in the intervention group compared to the control group (Kelly et al., 2017). Current research on the GAA 15 demonstrates that it improves neuromuscular outcomes (O'Malley et al., 2017) and enhances injury prevention (Schlingermann et al., 2017; Kelly et al., 2017) in male Gaelic games players. To date, no published research is currently available on the benefits and effectiveness of the Activate GAA warm up or the effectiveness of either Gaelic games IPP in Ladies Gaelic football.

2.6.2 Coaches Attitudes towards Injury Prevention

Coaches' knowledge and attitude towards injury prevention can influence injury prevention implementation (Norcross et al., 2016). To enhance the impact and benefits of injury prevention it is essential to have an understanding of coaches, players and staff member's perception of injury prevention programmes (O'Brien & Finch, 2016). While research has shown that coaches are willing to support the inclusion of injury prevention programmes and recognise their value, they often report a lack of knowledge and feel unequipped to implement preventative programmes (Twomey et al., 2015).

The implementation of IPP among coaches is low and varied with 21% of high school coaches (Norcross et al., 2016), 19.8% of girls' soccer coaches (Joy et al., 2013) implementing an IPP, and 7.7% male Gaelic football coaches implementing the GAA 15 (Reilly & Kipps, 2017) and 6% junior male soccer coaches and backroom staff implementing the FIFA 11 (O'Brien & Finch, 2016). Positive attitudes towards IPP, the perceived need for IPP and the ease of implementation in real-world setting may influence a coaches' decision to implement an IPP and one general explanation for the

lack of implementation may be a lack of awareness (Norcross et al., 2016). Only 52% of high school coaches (Norcross et al., 2016) and 74% of rugby coaches (Sewry et al., 2017) were currently aware of IPPs. The main motives for ACL IPP implementation by girls' soccer coaches included; injury prevention (93%) and improved performance (36%) (Joy et al., 2013) and junior netball coaches also identified a reduction in injuries (79%) and improvements in athletic attributes (83%) as a benefit of the IPP implementation (Saunders et al., 2010). Training duration and time constraints were one of the commonly reported barriers to IPP participation, reported by 63% of junior netball coaches (Saunders et al., 2010), 30% of high school coaches (Norcross et al., 2016) and 43% of girls' soccer coaches (Joy et al., 2013). Additionally, a lack of knowledge or skills to implement an IPP has also been identified as a barrier to implementation by 64% girls' soccer coaches (Joy et al., 2013) and 42% of junior netball coaches (Saunders et al., 2010), however this was not a main contributing factor for high school coaches (Norcross et al., 2016). For high school coaches conducting similar activities in their current sessions (65%), and players unwilling to participate (25%) were additional barriers of concern (Norcross et al., 2016).

Recent provisional research on male Gaelic football club coaches reported a wide-scale acceptance of the benefits of injury prevention programmes with 96% of coaches believing IPP would reduce both training and match injuries (Reilly & Kipps, 2017). However, a very poor implementation rate of these preventative strategies was observed with only 7.7% of coaches using a specifically tailored injury prevention programme for the GAA the GAA 15 (Reilly & Kipps, 2017). Although a small percentage of coaches reported specifically using the GAA 15 IPP, all coaches investigated using aspects of the IPP such as strength, balance and core exercises (Reilly & Kipps, 2017). However, caution must be taken with the results of this study as a relatively small sample size (n= 26) from male Gaelic football club coaches was analysed and to date only provisional results were available. Although recent research has investigated the understanding and perception of injury prevention with male Gaelic football coaches and in other sports, to the author's knowledge, no research has examined the willingness to participate or current participation levels in Ladies Gaelic football has been reported for either of the above-mentioned Gaelic games specific IPPs or any IPP.

Chapter 3

Injuries in Adolescent Ladies Gaelic Footballers

3.1 Abstract

Background: Participation in sport has an inherent risk for the potential development of musculoskeletal injuries. These sports-related musculoskeletal injuries can lead to significant financial and resource burdens. No published research has examined injury incidence or characteristics in female adolescent Gaelic footballers to date.

Aims: This study aimed to identify the incidence and characteristics of musculoskeletal injuries and to examine training loads reported by adolescent Ladies Gaelic footballers.

Methodology: Adolescent females (n= 109, 14.18 ± 1.00 years, 160.9 ± 6.5 cm, 57.7 ± 10.3 kg) from U-14 and U-16 Ladies Gaelic football club teams were recruited from the Midlands area. Prospective injury assessments were conducted weekly and recorded on a standardised injury report form. Pre-participation questionnaires gathered data on injury history and sports/ PA participation history. Self-completed written weekly training logs examining Gaelic football exposure levels were also completed, with training loads calculated using session duration and session rate of perceived exertion data.

Results: Prospective injury incidence rates of 10.32 per 1,000 hours were observed in club level adolescent Ladies Gaelic footballers, with U-16 players (23.24 per 1,000 hours) displaying a higher incidence rate than U-14 players (7.53 per 1,000 hours). Acute (55%) and new injuries (70%) were more commonly reported than overuse injuries (45%) and recurrent (25%) or persistent (5%) injuries. Lower extremity injuries were predominant, accounting for 70% of injuries. The calf (30%) and knee (20%) were the most frequently injured. Retrospectively, 58.8% of participants reported sustaining an injury while participating in physical activities and sports for the previous 12 months, where 57.9% of injured participants reported sustaining more than one injury. The most commonly reported injury locations retrospectively reported were the knee (26.3%), ankle (12.3%) and fingers (10.5%).

Conclusion: Adolescent Ladies Gaelic footballers were found to be vulnerable to injury, particularly older adolescent. Injuries to the lower extremity were prominent. Thus, the implementation of injury prevention programmes and an investigation of potential barriers to implementation of injury prevention programmes to minimise injury risk is vital.

3.2 Introduction

Participation in PA in Ireland is continuing to rise in adolescent females, and participation in team sports, like Gaelic football, has increased from 69.1% in 2013 to 75.6% in 2015 (Ipsos MRBI, 2016). Increasing levels of PA participation is a welcome trend for both the associated health benefits and socioeconomic benefits. Ladies Gaelic football is one of Ireland's national sports governed by the Ladies Gaelic Football Association (LGFA) and is recognised as one of the fastest growing female sports across Europe (Ladies Gaelic Football Association, 2011 a; Ladies Gaelic Football Association, 2011 b). Gaelic football has been described as a multi-directional, high-intensity, high-velocity, contact field sport, where speed, strength and agility are required to perform the intermittent short and fast skills required to play the game, such as sprinting, turning, catching, jumping and kicking (Murphy et al., 2012; Schlingerman et al., 2017). Due to the substantial levels of physical contact, biomechanical stresses (acceleration, deceleration and turning at high speeds), and repetitive bouts of vigorous efforts, Gaelic football players are exposed to the risk of injury (Reilly & Doran, 2001; Wilson et al., 2007; Murphy et al., 2012).

An injury can be described as any mechanical disruption to normal healthy tissue resulting in pain, wherein a traumatic event violates the integrity of the injured tissue, with its mechanical structures disturbed (Kumar, 2001). Injuries occur when an energy, commonly mechanical energy, is transmitted to the body at amounts or rates greater than the threshold for damage to occur to normal human tissue (Meeuwisse et al., 2007). Gaelic football injuries can have negative consequences and create a significant burden on players, substantially impacting a player's sporting and daily life. This impact may be as a result of trauma, pain, loss of function, financial costs or psychological effects that occur due to injury which can also lead to time lost in both education and sport (Murphy et al., 2012; O'Connor et al, 2016). Sports-related injuries in adolescents may also prevent participation in future physical activities that may be beneficial to their overall health and well-being (Weber et al., 2016).

To date, no published research has examined musculoskeletal injury incidence in adolescent female Gaelic football, with the majority of research conducted on males (O'Connor et al., 2016; O'Connor et al., 2017) and elite males specifically (Murphy et al., 2014; Cromwell et al., 2000; Newell et al., 2006). Previous research has been conducted on club level senior Ladies Gaelic footballers retrospectively investigating their injury incidence and characteristics. An injury incidence of 1.88 injuries per injured player was

noted, and 74.3% of participants reported sustaining an injury (Brown et al., 2013). In adolescent male Gaelic footballers an injury incidence of 4.89 injuries per 1,000 playing hours was reported (O'Connor et al., 2016). Injuries to the lower extremity were prominent in both club level senior Ladies Gaelic football and adolescent male Gaelic footballers, with injuries to the ankle and knee commonly occurring (Brown et al., 2013; O'Connor et al., 2016). In addition, injuries to the fingers were frequent in club level Ladies Gaelic footballers (Brown et al., 2013).

Data on the injury incidence and characteristics in adolescent Ladies Gaelic football may provide valuable information to inform medical care planning at both club and national levels by highlighting the potential injury and financial burdens and time lost from participation associated with these injuries. The identification of injury trends and patterns can also form the basis of injury prevention strategies. Therefore, the aim of this study was to establish the musculoskeletal injury incidence and characteristics of injuries in adolescent Ladies Gaelic footballers.

3.3 Methodology

3.3.1 Participants

One hundred and nine adolescent club Ladies Gaelic footballers from under-14 (n= 61) and under-16 (n= 48) club teams in the Midlands region were recruited. Clubs were recruited via direct contact by the primary investigator through both email and phone, where club contact details were located online or through known contacts within the Institute. Clubs located within the Athlone region were contacted first due to time restrictions with weekly travelling. The inclusion criteria for participation in this study included; adolescent females participating on a U-14 or U-16 club ladies Gaelic football team and did not meet any of the exclusion criteria. The exclusion criteria for participation included; any adolescent female players not participating in the U-14 or U-16 club teams, that may be younger or older, and any player who did not return a fully completed informed consent form. All participants took part in club level Gaelic football however, they were not restricted in terms of participation in other age categories, other levels including county and school and other sports and PA.

Injury data was collected for a mean of 10.5 ± 7.7 weeks over a total six-month period from April to September 2017. The time period of data collection varied between teams due to the knock out design of the competitions. Data collection started during early in-season for all U-14 teams (3) and for two out of three U-16 teams, with the final U-16 starting in the middle of the season and all data collection finished once the teams had reached the end of their season. All participants received a volunteer information sheet (Appendix A) and consent form (Appendix B) during a question and answer session conducted in the club. Prior to participation in the study the informed consent forms, signed by both the participant and parent/ guardian, were returned to the primary investigator and screened for full completion. Ethical approval was granted by the Athlone Institute of Technology Research Ethics Committee.

3.3.2 Study Design

Using a prospective cohort study design, quantitative research was conducted through the use of injury assessments, corresponding injury report forms and weekly training logs. Retrospective mixed methods research was also conducted through the use of a written pre-participation questionnaire. Testing was completed by the primary investigator, a Graduate Sports Rehabilitator, with assistance from two Certified Athletic and

Rehabilitation Therapists who assisted with baseline data collection. Prior to assisting with any data collection both Certified Athletic and Rehabilitation Therapists were provided with the data collection protocols and conferred on the data collection methods and criteria with the primary investigator. All data collected was returned to the primary investigator for observation, input to the database and storage. All data collected was stored by the primary investigator.

3.3.3 Pre-Participation Screening

Pre-participation testing was completed in the designated team changing room in each club where participants completed the pre-participation questionnaire investigating PA and sports participation history and injury history over the preceding twelve-months (Appendix C). The data collected in the pre-participation questionnaire is displayed in Table 3.1. Participant height to the nearest 0.1 centimetres (SECA Leicester Portable Height Measure, SHCA 799 SECA LTD.) and weight to the nearest 0.1 kilograms (SECA Heavy Duty Scales, SHCA 799 SECA LTD.) was also measured.

Table 3.1: Participation and injury history data collected in the pre-participation questionnaire

Participation History
Current sports/PA participation
Average hours participation per sport/PA a week
Time involved in sport/PA (years & months)
Level of Participation (e.g. club, county, school)
Usual playing position if applicable
Injury History
Any injury sustained in the previous 12 months
Number of injuries sustained
Location of most severe injury sustained
Recurrence of most severe injury
Treatment received for most severe injury if any & source if applicable
If a scan or surgery was required
Any time lost from sport/PA or school
Any injury rehabilitation completed
Participants view if adequate rehabilitation was completed prior to returning to participation & why not if applicable
Participants view if return to participation too early
Participants view of pressure to return to participation & source if applicable
Participants view if current performance similar to pre-injury and why not if applicable

3.3.4 Training Logs and Training Loads

Weekly hand-written training logs were completed during team training sessions or matches (Appendix E). All Gaelic football training sessions and/or matches completed in the previous week, as well as participation in all other types of PA or sports, were recorded in the training logs. Playing position, duration or time played, session intensity and details of any injuries sustained were also recorded. Data collected from the training logs were used to investigate training loads and exposure levels to Gaelic football in order to report injury rates. Weekly completion rates for training log were collected by assessing the number of training logs returned each week and calculating the percentage returned.

Training loads were calculated using session duration and session RPE data recorded in the weekly training logs. Session intensity was measured using the RPE scale which extends from 0 which is classified as rest to 10 which is classified as maximal difficulty (Figure 3.1) (Comyns & Flanagan, 2013). Training loads were calculated by multiplying

session durations by the session RPE and reported in arbitrary units (AU) (Equation 3.1) (Comyns & Flanagan, 2013). All training and match/ competition exposures for all sports at all levels were included for analysis.

0	Rest
1	Very Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

Figure 3.1: Session RPE Scale (Comyns & Flanagan, 2013)

$$\text{Training Load} = \text{Session Duration} \times \text{Session RPE}$$

Equation 3.1: Training Loads (Comyns & Flanagan, 2013)

3.3.5 Injury Assessments

Injury assessments were completed weekly during each team's training session or match depending on the team's weekly schedule. Both Gaelic football injuries and other sport/PA related injuries were assessed and logged. Injury report forms were used to standardise data collection during the musculoskeletal assessments (Appendix D). The data collected in the injury report forms can be seen in Table 3.2. Prior to assisting with any data collection, the two Certified Athletic and Rehabilitation Therapists were provided with the data collection protocols and conferred on the data collection methods and criteria with the primary investigator. All data collected was returned to the primary investigator for observation, input to the database and storage. All data collected was stored by the primary investigator.

Table 3.2: Data collected in the Injury Report Forms

Data Collected in Injury Report Forms	
Sport/ PA participating in at time of injury	Previous onset time if recurrent
Type of competition or training	Recovery/ rehab time if recurrent
Team injured with if applicable (e.g. club U-14, county U-16)	Any time lost from sports/PA if recurrent
Playing position at the time of injury	Any protective equipment worn
Surface playing on	Injured body part (e.g. head, ankle)
Time when injured	Mechanism of injury
Pain (VAS) at injury onset and assessment	Nature of Injury (e.g. sprain, strain)
Injured Side	Injury diagnosis
Acute/Chronic/Overuse Onset	Referral Advised
New/Recurrent Onset	Referral Type Advised

An injury was defined as any injury sustained during training or competition resulting in restricted performance or time lost from play (Cromwell et al., 2000; O'Connor et al., 2016). Injuries were further classified as time loss and non-time loss injuries, where time loss was classified as any time loss from Ladies Gaelic football ≥24 hours. Injury diagnosis was classified similar to the Orchard Sports Injury Classification System (Orchard et al., 2010), where the diagnosis was specific to location, structure injured and the grade where applicable (e.g. hamstring strain- biceps femoris strain grade 1). Injury severity was classified by the number of days from the date of injury occurrence to the date of full unrestricted participation (O'Connor et al., 2016). Injuries were classified into minor, (injuries lasting seven or fewer days), moderate (injuries lasting between eight and 21 days) and severe injuries (more than 21 days) (O'Connor et al., 2016). Recurrent injuries were defined as any injury of the same type and site as the original injury that occurred after a participant returned to full participation (O'Connor et al., 2016; Murphy et al., 2012). Fatigue-induced muscle disorders were classified using the Munich consensus statement where fatigue-induced muscle disorders was used to classify muscle injuries reported as "tightness" or as a result of overexertion and alterations to either training patterns or surface (Mueller-Wohlfahrt et al., 2013). An injury to the dominant side of the body was defined as the preferred kicking leg for the lower extremity and the preferred writing hand for the upper extremity.

3.3.6 Data Analysis

3.3.6.1 Training Loads Data Analysis

All training and match/ competition exposures reported for all sports and PA in the weekly training logs were included for analysis. Twenty-three injuries from 19 participants including three injuries sustained by adolescent Ladies Gaelic footballers while participating in Gaelic football for their school, were included in the analysis between injury and training loads. The data was analysed using IBM Corp. Released 2016 IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp). The data were checked for missing data and outliers and descriptive statistical analysis was completed. As the data collected did not meet the criteria for normal distribution using the Shapiro-Wilks normality tests for samples ≤ 50 and the Kolmogorov-Smirnov for samples >50, the non-parametric Mann-Whitney U tests were used to compare the differences in average training loads between; (1) U-14 (n= 50) versus U-16 (n= 34) players, (2) participation on one (n= 47) versus multiple (n= 37) Ladies Gaelic football club teams, (3) single sport (n= 35) versus multiple sports/PA (n= 49) participation and (4) injured (n= 19) versus uninjured (n= 76) players. Statistical significance was set at $p \leq 0.05$. Effect sizes were calculated using Cohen's d, where 0.2 was classified as a small effect, 0.5 as a medium effect and 0.8 as a large effect. Chi-square analysis was also conducted to assess for significant associations between injury occurrence and training loads greater than the sample average (n= 18), and the phi coefficient was analysed for the effect size.

3.3.6.2 Injury Epidemiology Data Analysis

All injuries sustained during club Ladies Gaelic football were included for analysis. The frequency of injury type, nature, onset, location, severity and outcome were analysed and reported using Microsoft Excel 2016. Mean time loss from participation and standard deviations for each injured location was calculated using Microsoft Excel 2016. Chi-square analysis using IBM Corp. Released 2016 IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp) was completed to assess for significant associations between prospective injury occurrence while participating in Ladies Gaelic football and retrospective injury occurrence in the previous 12 months while participating in sports/PA (n= 97), where the phi coefficient was analysed for the effect size. Injury incidence rates (IR) were calculated per 1,000 hours overall and for match and training sessions individually, using Equation 3.2, 3.3 and 3.4 below (O'Connor et al., 2016; O'Connor et al., 2017). Club match and training exposure was gathered from the weekly

training logs, where the mode of completed weekly training logs was used to estimate the weekly exposure for missing participants' training logs. The Poisson confidence intervals (CI) at 95% for each of the injury rates were calculated using Equation 3.5 and Equation 3.6. Incidence proportion, repeat incidence proportion and clinical incidence were also calculated using Equation 3.7, 3.8 and 3.9 (O'Connor et al., 2016; O'Connor et al., 2017). The repeat incidence proportion analysis was completed to identify the proportion of participants sustaining multiple injuries throughout the duration of the study. The Poisson confidence intervals (CI) at 95% for incidence proportions (Equation 3.4 and Equation 3.5) were completed in the same manner as the repeat incidence proportion and clinical incidence confidence intervals, where incidence proportion was substituted in place of incidence rates.

$$\text{Incidence Rate (IR)} = \frac{\text{Number of Injuries}}{\text{Total Playing Hours}} \times 1{,}000$$

Equation 3.2: Calculation of Incidence Rates per 1,000 hours

$$\text{Match IR} = \frac{\text{Number of Injuries}}{\text{Total Match Hours}} \times 1{,}000$$

Equation 3.3: Calculation of Match Incidence Rates per 1,000 hours

$$\text{Training IR} = \frac{\text{Number of Injuries}}{\text{Total Training Hours}} \times 1{,}000$$

Equation 3.4: Calculation of Training Incidence Rates per 1,000 hours

$$\text{Lower CI} = \frac{\text{IR}}{\text{EXP}(1.96/\sqrt{\text{Number of Injuries}})}$$

Equation 3.5: Poisson Confidence Intervals (95%) Calculation- Lower CI

$$\text{Upper CI} = \text{IR} \times (\text{EXP}(1.96/\sqrt{\text{Number of Injuries}}))$$

Equation 3.6: Poisson Confidence Intervals (95%) Calculation- Upper CI

$$\text{Incidence Proportion} = \frac{\text{Number of injured participants during a specific time}}{\text{Number of participants at risk during a specific time}}$$

Equation 3.7: Calculation for Injury Incidence Proportion

$$\text{Repeat Incidence Proportion} = \frac{\text{Number of repeat injured participants during a specific time}}{\text{Number of injured participants during a specific time}}$$

Equation 3.8: Calculation for Repeat Injury Incidence Proportion

$$\text{Clinical Incidence} = \frac{\text{Number of injuries during a specified time}}{\text{Number of participants at risk at start of specified time}}$$

Equation 3.9: Calculation for Clinical Incidence

3.4 Results

3.4.1 Participants

One-hundred and nine female adolescent Ladies Gaelic football club players participated in the study, with sixty-one U-14 and forty-eight U-16 players over a mean duration of 10.5 ± 7.7 weeks. Participant demographics are reported in Table 3.3 below.

Table 3.3: Participants Mean Anthropometric Characteristics

Mean	Overall	Under-14	Under-16
Age (years)	14.18 ± 1.00	13.87 ± 0.77	14.68 ± 1.07
Height (cm)	160.9 ± 6.5	157.6 ± 5.8	163.3 ± 6.1
Weight (kg)	57.7 ± 10.3	56.2 ± 9.9	59.2 ± 10.0

All adolescent Ladies Gaelic footballers participated at club level Ladies Gaelic football, with a further 15.5% of participants playing for their county team and 78.3% playing for their school team. The mean years of Gaelic football participation were 5.68 ± 0.26 years. Forwards (43.8%) and backs (42.7%) accounted for the majority of positions reported, with the remainder split between midfielders (10.4%) and goalkeepers (4.2%). In addition to their own club age category, 39.2% of participants played on an older age category for their club and an additional 60.8% of participants reported participating in other sports and physical activities (Table 3.4). Basketball (15.2%) and fitness classes (15.2%) were the most commonly reported activities outside of Gaelic football reported. Team sports participation accounted for 53.2% of additional activities and individual sports participation accounted for 46.8%.

Table 3.4: Additional sports and physical activity participation levels in adolescent Ladies Gaelic footballers

Additional Sports and Physical Activity Participation		
Sport/PA	*Number of Participants*	*Percentage of Participation*
Basketball	12	15.2%
Fitness Class	12	15.2%
Hockey	10	12.7%
Camogie	10	12.7%
Horse Riding	7	8.9%
Soccer	6	7.6%
Athletics	5	6.3%
Rugby	4	5.1%
Dancing	4	5.1%
Gymnastics	3	3.8%
Swimming	2	2.5%
Taekwondo	1	1.3%
Karate	1	1.3%
Boxing	1	1.3%
Kickboxing	1	1.3%

3.4.2 Prospective Ladies Gaelic Football Epidemiological Results

Twenty injuries were sustained by 16 Ladies Gaelic footballers, during 1,938.20 hours of club Ladies Gaelic football exposure. Twelve injuries were sustained by U-14 players over 1,593.92 hours of playing exposure and eight injuries were sustained by U-16 players during 344.28 hours of exposure. Injuries during match participation accounted for 65% (n= 11) of injuries and injuries during training accounted for 35% (n= 7) of injuries. Time loss injuries (≥ 24 hours) accounted for 40% (n= 8) of injuries reported. Fifty-five percent (n= 11) of injuries resulted in no time lost from participation.

3.4.2.1 Injury Incidence

The injury rate, incidence proportion and clinical incidence proportion for all injuries are presented in Table 3.5. Overall 14.7% of adolescent Ladies Gaelic footballers sustained an injury, which was higher in U-14 players (16.4%) but not significantly greater than reported in U-16 players (12.5%). However, although not statistically significant, a higher injury incidence was noted in U-16 (23.24 injuries per 1,000 hrs; 95% CI- 11.62-46.46) than U-14 players (7.53 injuries per 1,000 hrs; 95% CI- 4.28-13.26), with an overall

incidence of 10.32 injuries per 1,000 hrs noted. Although match injury incidence (17.60 injuries per 1,000 hrs; 95% CI- 10.22-30.32) was over three times greater than that observed for training injury incidence (5.83 injuries per 1,000 hr; 95% CI-2.78-12.24), it was not significantly greater. A significantly greater match injury incidence was observed in U-16 players (66.06 injuries per 1,000 hrs; 95% CI- 29.68-147.03) compared to U-14 players (10.81 injuries per 1,000 hrs; 95% CI- 5.15-22.67), where the match injury incidence was over six times greater in U-16 players.

Table 3.5: Incidence proportion, repeat incidence proportion, clinical incidence and incidence rate of injury for adolescent Ladies Gaelic football

		Injury Incidence	95% CI
Incidence Proportion	Overall	0.147	0.090-0.240
	U-14	0.164	0.088-0.305
	U-16	0.125	0.056-0.278
Repeat Incidence Proportion	Overall	0.250	0.094-0.666
	U-14	0.200	0.056-0.806
	U-16	0.333	0.083-1.333
Clinical Incidence	Overall	0.183	0.087-0.385
	U-14	0.197	0.082-0.473
	U-16	0.167	0.042-0.666
Injury Incidence Rate per 1,000 hours	Overall	10.32	6.66-15.99
	U-14	7.53	4.28-13.26
	U-16	23.24	11.62-46.46
Match Injury Incidence Rate per 1,000 hours	Overall	17.60	10.22-30.32
	U-14	10.81	5.15-22.67
	U-16	66.06	29.68-147.03
Training Injury Incidence Rate per 1,000 hours	Overall	5.83	2.78-12.24
	U-14	5.28	2.20-12.70
	U-16	7.89	1.97-31.55

3.4.2.2 Injury Characteristics

3.4.2.2.1 Injury Onset

Acute injuries accounted for 55% of injuries reported, with the remaining 45% overuse in nature. The majority of injuries reported were new onsets (70%) followed by recurrent (25%) and persistent (5%) onsets.

3.4.2.2.2 Injury Location

Injuries to the dominant side of the body accounted for over half of the injuries (55%) reported when compared to the non-dominant side (25%). Central injuries accounted for 5% of injuries reported and 15% of injuries reported were classified as bilateral injuries. Dominant side injuries were more prominent in lower extremity injuries (64%) compared to non-dominant or bilateral injuries, and non-dominant (67%) injuries were marginally more common in the upper extremity (Table 3.6).

Table 3.6: Injuries and Dominance in Adolescent Ladies Gaelic Football

Injury & Dominance								
	Total Injuries		*Lower Extremity*		*Upper Extremity*		*Head/ Spine*	
	n	*%*	*N*	*%*	*n*	*%*	*n*	*%*
Dominant	11	55%	9	64%	1	33%	0	0%
Non-Dominant	5	25%	3	21%	2	67%	0	0%
Bilateral	3	15%	2	14%	0	0%	2	67%
Central	1	5%	0	0%	0	0%	1	33%

* n= number of injuries; %= percentage of injuries

Injuries to the lower extremity accounted for 70% of club injuries reported in adolescent Ladies Gaelic footballers, with the remainder equally distributed between the upper extremity (15%) and head/ spine (15%). The Regional distribution of injuries is presented in Table 3.7, where the ankle/shin/calf (45%) was the most commonly reported region of injuries followed by the knee (20%). The calf (30%; 6) and knee (20%; 4) were the most commonly reported body part injured (Figure 3.2).

Table 3.7: Regional distribution of injuries in adolescent Ladies Gaelic football

Regional Distribution of Injury Locations		
Injury Region	*Number of Injuries*	*Percentage of Injuries*
Ankle/Calf/ Shin	9	45%
Knee	4	20%
Wrist/Hand/Fingers	3	15%
Spine	2	10%
Thigh	1	5%
Head	1	5%

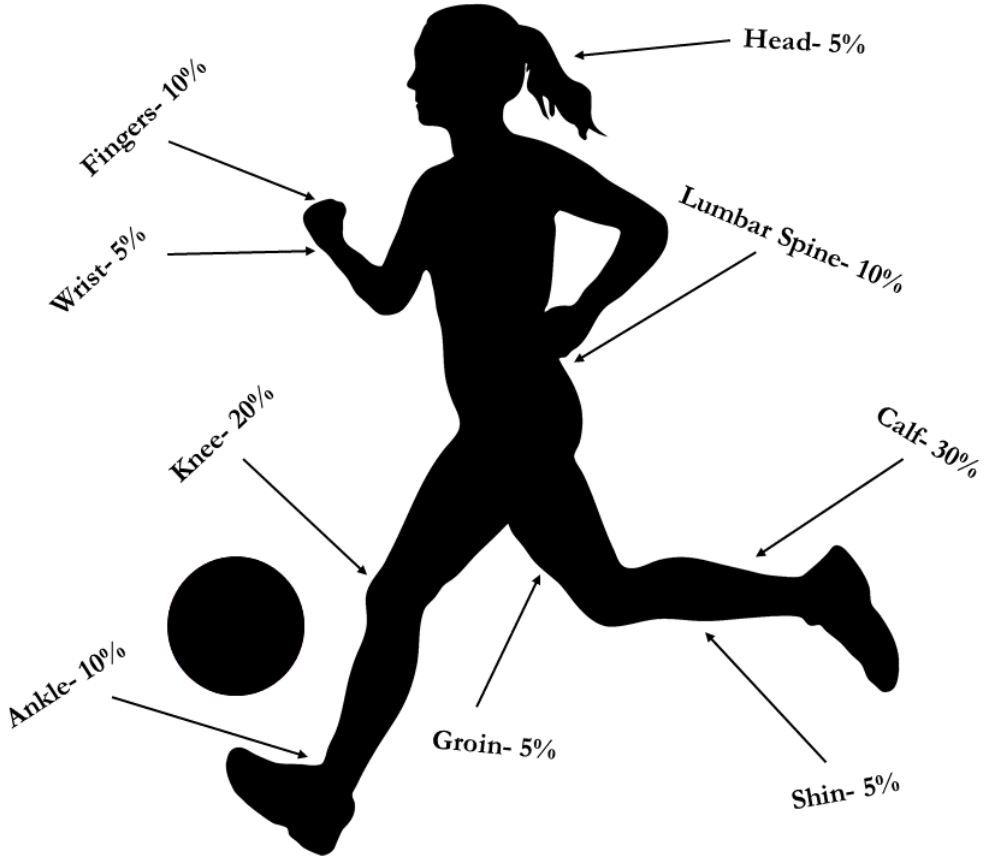

Figure 3.2: Distribution of injury locations in adolescent Ladies Gaelic football

3.4.2.2.3 Nature of Injury

Muscle injuries were the most commonly reported nature of injury accounting for 45% (n= 9) of injuries, followed by ligaments (35%; n= 7). The remainder of injuries were distributed between tendons (10%; n= 2), bone (5%; n= 1) and concussive injuries (5%; n= 1). The specific nature of injuries is presented in Table 3.8 where sprains (35%) and fatigue induced muscular disorders (35%) were the most commonly reported followed by tendinopathies (10%). The most common injuries reported were calf fatigue induced muscle disorders (25%; n= 2), finger sprains (10%; n= 2), lateral ankle sprains (10%; n= 2), lumbar facet joint sprains (10%; n= 2) and patellar tendinopathies (10%; n= 2). Two additional finger sprains and one hamstring strain were sustained by adolescent Ladies Gaelic footballers while participating in school Ladies Gaelic football and were not included for analysis as a result.

Table 3.8: Specific nature of injuries in adolescent Ladies Gaelic footballers

Nature of Injuries		
Injury Nature	*Number of Injuries*	*Percentage of Injuries*
Sprain	7	35%
Fatigue Induced Muscle Disorder	7	35%
Tendinopathy	2	10%
Strain	1	5%
Bone Bruise	1	5%
Contusion	1	5%
Concussion	1	5%

3.4.2.2.4 Mechanism of Injury

Non-contact injuries accounted for 65% of injuries reported with contact injuries accounting for the remaining 35% of injuries reported. The mechanisms of injury for adolescent ladies Gaelic footballers are displayed in Table 3.9 with running (35%) the most commonly reported injury mechanisms followed by contact with another player (25%).

Table 3.9: Mechanisms of injury in adolescent Ladies Gaelic football

Mechanism of Injuries		
Injury Mechanism	*Number of Injuries*	*Percentage of Injuries*
Running	7	35%
Contact- Another Player	5	25%
Non-Specific/ Gradual	4	20%
Contact-Ball	2	10%
Turning	1	5%
Falling	1	5%

3.4.2.2.5 Time of Injury Onset

Injury during the second half of matches was most frequent (46.1%; n= 6), compared to the warm-up (15.4%; n= 2) and the first half of games (38.5%; n= 5). Most training injuries occurring within the 31-60 minute of a training session (57.1%; n= 4) compared to the first 30 minutes (42.9%; n= 3). The majority of match injuries occurred in the second (30.8%; n= 4) and the final quarter (38.5%; n= 5), compared to the first (23.1%; n= 3) and third quarter (7.7%; n= 1).

3.4.2.2.6 Playing Position

The same percentage of injuries were reported in forwards (45%; n= 9) and backs (45%; n= 9), with a small proportion of injuries occurring in midfield players (10%; n= 2). When injuries were calculated per position, forwards and backs sustained the same proportion of injuries per position (1.5 injuries per position) compared to midfielders who reported 1.0 injuries per position. No injuries were reported in goalkeepers.

3.4.2.2.7 Injury Outcome

Most injuries reported were minor (85%) resulting in ≤ 7 days lost from participation, followed by moderate injuries (15%) resulting in between 8-21 days lost. No severe injuries which resulted in > 21 days lost from participation were reported. One injury reported during the duration of the study was referred for further X-ray imaging. No surgical interventions were required for any of the injuries reported. The ankle had the greatest mean time lost from participation (7 days), followed by the calf (1.7 days) and the knee (1 day). The fingers and lumbar spine had a mean time loss of 0 days, where all injuries (n= 4) reported resulted in no time lost. One concussion, wrist and thigh injury was reported which resulted in 10 days, 4 days and 3 days lost from participation respectively.

3.4.2.2.8 Training Loads

The mean weekly training log completion rate per week was 50.8% (± 17.4%). The total mean weekly training loads for all participants ranged from 50.00 arbitrary units (AU) to 5520.00 AU. The total mean weekly training load was 1065.00 AU (± 79.95 AU) for both U-14 and U-16 combined, 930.19 AU (± 62.41 AU) for U-14 players and 1296.11 AU (± 170.93 AU) for U-16 players. No significant differences between U-14 and U-16 mean weekly training loads were observed (p= 0.08; d= -0.51). The weekly training load mean for participants participating in additional levels of Ladies Gaelic football was medium significantly higher (p< 0.001, d= 0.68) than participants who participated at only one level. Similarly, the mean weekly training loads for participants participating in additional sports or PA was medium significantly higher (p= 0.001; d= -0.63) than participants who solely participated in Ladies Gaelic football (Table 3.10).

Over one-third (n= 7) of injured players reported training loads less than the total mean weekly training loads. One-quarter (n= 5) of injured participants reported training loads lower than 90% of the total mean weekly training loads, one-seventh (n= 3) reported

mean training loads less than 75% of the total mean and one-tenth (n= 2) reported training loads less than 50% of the total mean weekly training loads (Figure 3.3). All participants included in Figure 3.3 participated in club level adolescent Ladies Gaelic football, with 26.3% solely participating in Ladies Gaelic football and 73.7% participating in other sports or PA. Participants who sustained an injury had a small to medium significantly higher mean weekly training load of 1320.91 AU (± 119.90 AU) compared to uninjured participants (1001.02 AU ± 88.90 AU, p= 0.004; d= 0.48). Chi-square analysis showed a small significant (p= 0.003; φ= 0.30) association between participants with training loads greater than the total mean weekly training loads and sustaining an injury. Data relating to training loads in the week prior to injury was available for 78.3% (n= 18) of injuries reported. From the data available, 66.7% (n= 12) of participants reported training loads higher than their mean weekly training loads in the week prior to their injury. Training load data for the two weeks prior was available for 7 participants, where 71.4% (n= 5) of those also presented with training loads greater than their mean weekly training loads.

Table 3.10: Significant Differences in Training Loads

Variable 1	Mean TL (± SD)	Variable 2	Mean TL (± SD)	Significant Difference (p)	Effect Size (d)
U-14 Players	930.19 ± 62.41	U-16 Players	1296.11 ± 170.93	p= 0.08	d= 0.51
Solely Participating in Ladies Gaelic football	806.16 ± 522.44	Participation in additional Sports/PA	1252.03 ± 852.25	p= 0.001*	d= -0.63
Participation at One Club Level	844.04 ± 600.05	Participation at multiple Club levels	1348.55 ± 855.87	p< 0.001*	d= 0.68
Injured Participants	1320.91 ± 119.90	Uninjured Participants	1001.02 ± 88.90	p= 0.004*	d= 0.48

TL- Training Load measured in AU, ***-** Significant at p< 0.05

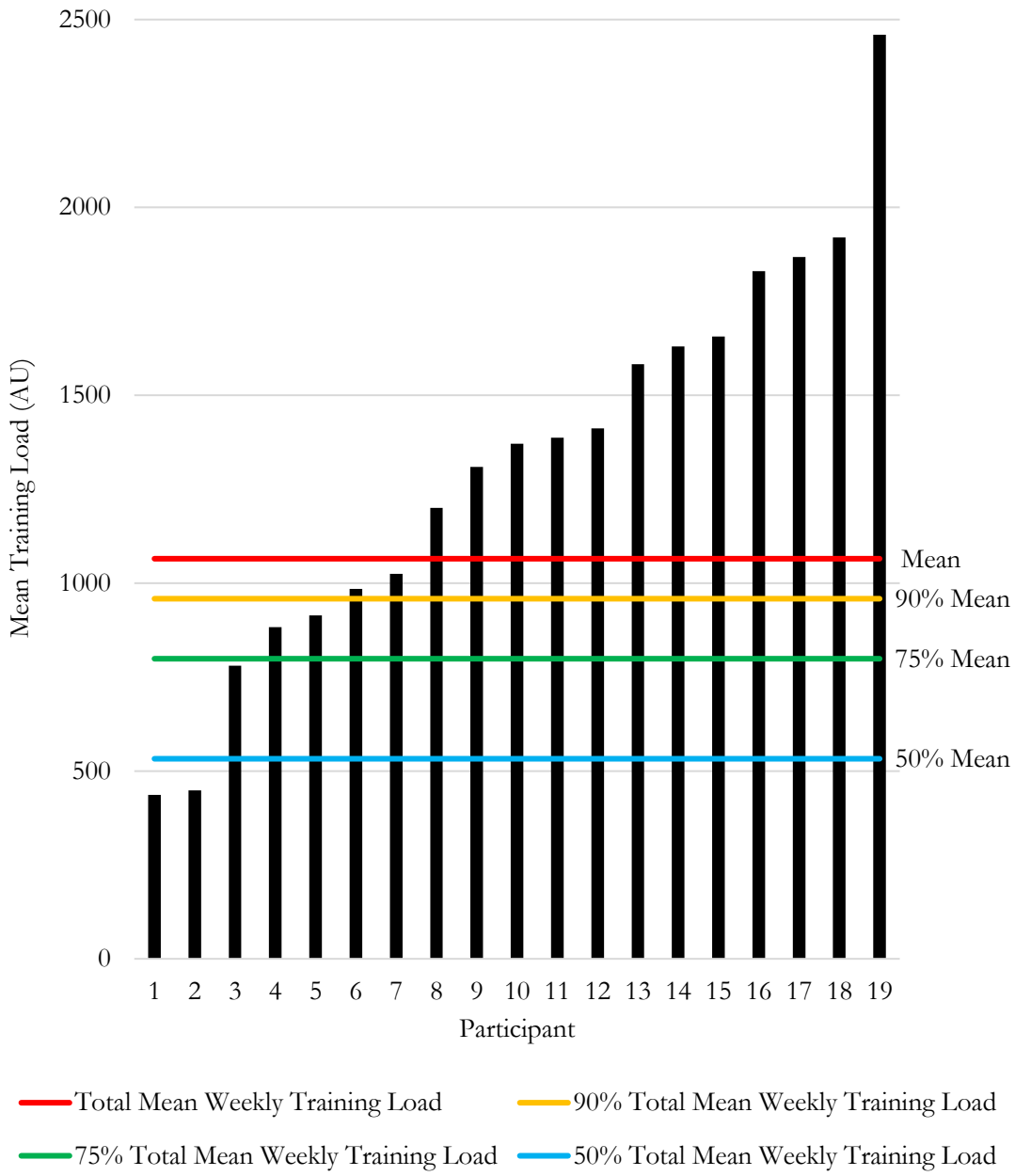

Figure 3.3: Mean Weekly Training Loads for Injured Players

3.4.3 Retrospective Physical Activity Epidemiological Results

Ninety-seven completed retrospective pre-participation questionnaires (89% of participants) were included for analysis from fifty-two U-14 players and forty-five U-16 players. Fifty-seven (58.8%) participants reported sustaining 105 injuries in the previous 12-month period while participating in sports or PA. Over half (55.8%) of U-14 players and 62.2% of U-16 players sustained an injury. Forty-two percent of participants injured reported sustaining one injury and 57.9% of injured participants reported sustaining two or more injuries over the same 12-month period (two injuries-38.6%; three injuries-12.3%; four injuries- 7.0%). Additionally, 73.7% (n= 14) of participants that sustained an injury prospectively while participating in Ladies Gaelic football also retrospectively reported sustaining an injury over the previous 12 months. A non-significant very small association (p= 0.141; φ= 0.15) between sustaining an injury in the previous 12 months while participating in sports/PA and the prospective occurrence of an injury while participating in Ladies Gaelic football was found.

3.4.3.1 Retrospective Injury Characteristics

3.4.3.1.1 Injury Location

The majority of the most severe retrospective injuries over the previous 12 months were to the lower extremity (73.7%), followed by the upper extremity (21.1%) and spinal/head (5.3%). The regional distribution of injuries can be seen in Table 3.11, where the knee (26.3%), finger/hand/wrist (19.3%) and the lower leg (17.5%) were the most commonly reported region of injury. Similarly, the knee (26.3%; 15) was the most common injured body part reported followed by the fingers (12.3%; 7) and ankle (10.5%; 7) (Figure 3.4).

Table 3.11: Regional distribution of retrospective injuries reported while participating in physical activities

Regional Distribution of Injury Locations		
Injury Region	*Number of Injuries*	*Percentage of Injuries*
Knee	15	26.3%
Finger/Hand/Wrist	11	19.3%
Lower Leg	10	17.5%
Toe/Foot/Ankle	9	15.8%
Thigh/Hip	8	14.0%
Spine/Head	3	5.3%
Elbow	1	1.8%

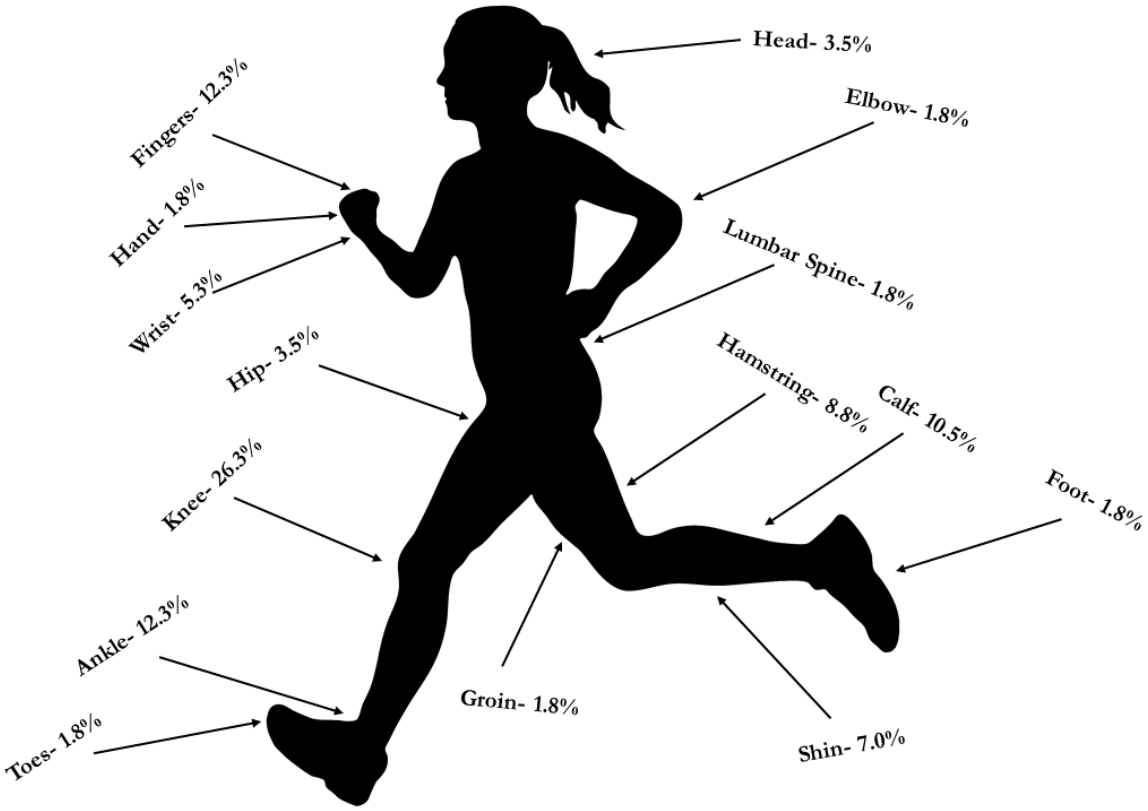

Figure 3.4: Distribution of the most severe injuries retrospectively reported by adolescent females while participating in physical activities

3.4.3.1.2 Injury Severity and Time Lost from Participation and School

Approximately half of the injuries (49.1%; n= 28) were minor (< 7 days lost). Severe injuries (> 21 days lost) accounted for 29.8% (n= 17) of injuries reported with 21.0% (n= 12) moderate injuries (8-21 days). Time lost (≥ 24 hours) from sports participation as a result of an injury was reported in 68.4% of injuries recorded (0-180 days). In 21.0% of injuries, participants missed time in school, ranging from 1 hour to 10 days. Concussion injuries (44.0 days) resulted in the greatest mean time loss from sports and PA participation, followed by calf injuries (38.7 days) and ankle injuries (29.3 days) (Table 3.12).

Table 3.12: Time lost from sport/ PA participation retrospectively reported while participating in physical activities

Time Loss Burden from Sports/PA Participation		
Injury Location	*Number of Injuries*	*Mean Time Loss (Days)*
Head	2	44.0 days ± 22.6
Calf	6	38.7 days ± 70.1
Ankle	7	29.3 days ± 45.2
Shin	4	25.5 days ± 43.1
Knee	15	24.7 days ± 47.9
Hamstring	5	14.4 days ± 20.5
Fingers	7	9.1 days ± 10.3
Wrist	3	6.0 days ± 10.4

3.4.3.1.3 Injury Treatment and Return to Participation

Of the fifty-seven participants reporting an injury, 68.4% reported receiving treatment for their injury. Further investigations were reported in 35.1% of injuries. Of these, an X-ray was the most commonly utilised (80.0%), followed by CT Scans (10.0%), MRI (5.0%) and Ultrasound (5.0%). No surgical interventions were reported. Less than half of all participants injured (45.6%) completed any type of rehabilitation for their injury. Of the 45.6% (n= 26) who reported completing rehabilitation, 23.1% (n= 6) felt as though they had not completed adequate rehabilitation prior to return to participation and 29.8% of participants felt they had prematurely returned to participation. Overall one-third (33.3%; n= 19) of injured participants reported feeling pressure to return to participation, with 47.1% (n= 8) of participants who felt they returned to participation prematurely, reported feeling pressure to return. The main sources of pressure to return to participation were; from themselves (68.4%; n= 13), coaches (10.5%; n= 2), parents (10.5%; n= 2) or others not specified (10.5%; n= 2).

Of the participants reporting an injury both prospectively and retrospectively (n= 14), 85.7% (n= 12) reported receiving treatment and 71.4% (n= 10) reported completing rehabilitation for their retrospectively reported injury. Over half (57.1%; n= 8) of participants reported feeling they had completed adequate rehabilitation prior to return to participation, with a lower percentage (28.6%; n= 4) reported feeling they returned to participation prematurely. Most participants (78.6%; n= 10) reported feeling as though they had returned to a similar level of performance post-injury as pre-injury.

3.5 Discussion

The aim of this study was to establish the musculoskeletal injury incidence and injury characteristics in adolescent Ladies Gaelic footballers, prospectively during Gaelic football participation only and retrospectively recalling all sports and PA related injuries from the previous twelve months. Although participation in Ladies Gaelic football is one of the most popular types of PA for adolescent females in Ireland (Woods et al., 2010), injury epidemiology research (Brown et al., 2013; Crowley et al., 2011) is limited, with no previous research on adolescent Ladies Gaelic footballers currently available.

3.5.1 Injury Incidence

Less than one-sixth of adolescent Ladies Gaelic footballers were at risk of sustaining an injury while participating in Ladies Gaelic football, over a mean duration of 10.5 ± 7.7 weeks. Overall injury incidence (10.32 injuries per 1,000 hrs; 95% CI- 6.66-15.99) was significantly greater than the injury incidence in adolescent males (4.89 injuries per 1,000 hrs; 95% CI- 4.02-5.73) (O'Connor et al., 2016) and although not significant, adolescent Ladies Gaelic footballers had a greater injury incidence when compared to collegiate male Gaelic footballers (12.6 injuries per 1,000 hrs; 95% CI- 10.7-14.9) (O'Connor et al., 2017). The significantly greater injury incidence in adolescent females compared to their male counterparts may be because of smaller playing populations in Ladies Gaelic football, particularly in smaller rural clubs, requiring players to participate in multiple club teams increasing player exposure and training loads and reducing recovery times, which was observed in the current study where injured adolescent females reported mean training loads 27.5% greater than uninjured players. In the current study over one-third of players reported playing on an additional club team at an older age category, as well as up to two-thirds of players playing on a school team and one-sixth of players playing on their county team. Injury rates in adolescent Ladies Gaelic football were also higher than reported in adolescent female soccer players (5.6-6.8 injuries per 1,000 hours) (Emery et al., 2005 b; Söderman et al., 2001 a; Le Gall et al., 2008), however this may be due to the playing nature of both games with the upper extremity more predominantly used compared to soccer (Brown et al., 2013).

Although not statistically significant, match injury incidence was approximately 3.0 times greater than training injury incidence in adolescent Ladies Gaelic football. A significantly greater match injury incidence was found in U-16 (66.06 injuries per 1,000 hrs; 95% CI-

29.68-147.03) compared to U-14 players (10.81 injuries per 1,000 hrs; 95% CI- 5.15-22.67) which may be as a result of greater levels of physicality with an increase in age (Brown et al., 2017; O'Connor et al., 2017). This finding has also been noted in male adolescent Gaelic footballers, whereby male secondary school players and male adolescent players had approximately a six (Watson, 1996) and three times (O'Connor et al., 2016) greater injury incidence during matches than training. Similarly, in adolescent female soccer (22.4 vs 4.6 injuries per 1,000 h) (Le Gall et al., 2008), greater injury incidences during matches were observed. The increased intensity and effort, greater levels of physicality and competitiveness and desire to win associated with matches may account for the greater injury incidence observed during matches (Wilson et al., 2007; O'Connor et al., 2016). The lower injury incidence observed during training compared to matches may be because of the reduction in intensity and physicality during training sessions, as not all aspects of training may be replicating a match intensity with non-contact skills session common (Murphy et al., 2012). Additionally, training sessions are a controlled environment where coaches control the intensity and physicality levels depending on the training session. Further information, resources and training for coaches on current training practices and the physiological demands in Ladies Gaelic football matches should be provided to assist coaches with the provision of training sessions that mimic the intensity and physicality required during matches, allowing players to develop a tolerance to the demands of match play (Malone et al., 2017 c). However, caution must be taken when implementing these high intensity sessions, with strict periodisation and monitoring as large spikes in acute workloads and high chronic workloads may increase a players' risk of injury (Malone et al., 2017 c). A 1.9-times greater match injury incidence was found in adolescent Ladies Gaelic football (17.60 injuries per 1,000 hrs) compared to adolescent male Gaelic football (9.26 injuries per 1,000 hrs) (O'Connor et al., 2016). Adolescent female training injury incidence was also 1.9 times greater than injury incidence observed in adolescent males (O'Connor et al., 2016; Watson, 1996).

Over half (58.8%) of all players entered the new season following a sports/PA related injury in the previous 12 months, where 57.9% of those reported sustaining two or more injuries. In addition, one-quarter of all injured participants sustained a subsequent injury in the current season, with three-quarters of injured players reporting a sports/PA related injury in the previous year. A higher repeat injury incidence was observed in the U-16 Ladies Gaelic footballers, where one-third of injured participants sustained multiple

injuries. This high proportion of repeat injuries is also shown in adolescent male Gaelic footballers and hurlers (26.3%) (O'Connor et al., 2016) and collegiate male Gaelic footballers (25.2%) (O'Connor et al., 2017). Premature return to participation without adequate rehabilitation or continued participation while injured have been suggested as contributing factors for the high repeat injury incidence proportion within Gaelic football (O'Connor et al., 2016; O'Connor et al., 2017; Murphy et al., 2012), where less than half of adolescent female players reported completing any form of rehabilitation and approximately one-third of players felt as though they prematurely returned from injury in the previous year. Educational programmes for players on the importance of and potentially negative implications of not completing sufficient injury rehabilitation prior to return to participation may assist in the reduction of repeat and recurrent injuries, as 68.4% of players identified themselves as the main source of pressure to return to participation. The identification of the specific risk factors for injury within adolescent Ladies Gaelic football and their management protocols may also assist in the reduction of repeat and recurrent injuries.

3.5.2 Injury Event

Acute injuries were slightly more predominant (55%), similar to adolescent male Gaelic football (73.3%) (O'Connor et al., 2016) and female adolescent soccer (86.4%) (Le Gall et al., 2008). Over one-third (45%) of injuries in adolescent Ladies Gaelic football were overuse in nature, greater than that reported in adolescent male Gaelic footballers (26.7%) (O'Connor et al., 2016), female adolescent soccer players (34%) (Söderman et al., 2001 a) and collegiate male Gaelic footballers (21.1%) (O'Connor et al., 2017). Differences in biological and chronological age, the adolescent growth spurt, muscular imbalances, differential growth, poor technique and underdeveloped co-ordination and skills development reported in young athletes may be contributing to the higher injury incidence of overuse injuries in adolescent Gaelic footballers (Caine et al., 2014; Ukogu et al., 2017). While current injury prevention programmes focus on neuromuscular training aiming to reduce the high incidence of lower extremity non-contact injuries in Gaelic games (O'Malley et al., 2017; Schlingermann et al., 2017), the inclusion of athlete monitoring as discussed by Roe et al. (2017) in the Operational framework for managing injury risk which includes elements of training load management, player wellness and session RPE monitoring and strength monitoring in conjunction with biomechanical

assessments and re-training and player education into recovery and training load management may assist with the reduction of overuse injuries.

While new injuries were most frequent, approximately one-third of injuries reported were recurrent (25%) and persistent (5%) onsets, with approximately half of adolescent male Gaelic football (47.3%) and one-third (33.3%) of male adolescent hurling (O'Connor et al., 2016) injuries reported as recurrent or persistent injuries. A commonly observed trend was players continuing to participate while injured or not receiving treatment for their injuries. Less than a third of players retrospectively reported not receiving treatment for their injury and less than half of players completed any form of injury rehabilitation, which may have contributed to the high presence of recurrent and overuse injuries in adolescent Gaelic games. The development of injury prevention strategies to include; training load monitoring, increased emphasis on proper player biomechanics, and particularly ensuring the completion of player injury rehabilitation prior to return to play and an educational program informing players and coaches of the negative effects of playing while injured (O'Connor et al., 2016), should be adopted in attempt to reduce the incidence of recurrent and persistent injuries. Although not specific to the importance of injury treatment and rehabilitation, an educational intervention for athletic youths on the importance of hydration status for performance found significant increases ($p < 0.05$) in player hydration status and performance (Kavouras et al., 2012), indicating that an injury and injury rehabilitation educational intervention may be beneficial for adolescent Ladies Gaelic footballers.

The majority of injuries reported in adolescent Ladies Gaelic footballers were to the lower extremity, both prospectively (70%) and retrospectively (73.7%), substantially higher than reported in senior club level Ladies Gaelic footballers (46.9%) (Brown et al., 2013) but lower than that in adolescent male Gaelic footballers (74.7%) (O'Connor et al., 2016). The high proportion of lower extremity injuries in Gaelic football may be linked to the physical demands and skills required to participate such as; running, kicking, jumping, side-stepping and changing direction at pace (Cromwell et al., 2000). Future examinations of the current use of Gaelic games specific injury prevention programmes (IPP) within Ladies Gaelic football and the effects of the GAA 15 or Activate GAA Warm-Up should be investigated to assess the need for developing a Ladies Gaelic football specific IPP or focusing on current IPP implementation strategies and educational programmes. Although the majority of injuries sustained were to the lower extremity, upper extremity injuries account for between one-sixth to one-third (Brown et al., 2013) of injuries in

Ladies Gaelic football, highlighting the importance of considering including upper extremity elements while implementing injury prevention programmes for Ladies Gaelic footballers specifically. Playing mechanics and technique, such as catching and passing the ball that require high levels of ball to hand/ finger contact should be included in injury prevention strategies for Ladies Gaelic football in attempt to reduce the injury incidence to the hand and fingers overserved in both adolescent and adult club level (Brown et al., 2013), while also potentially benefiting players' performance and skill levels.

Over half (55%) of injuries reported occurred on the dominant side, with the majority of lower extremity injuries (64.3%) occurring to the dominant limb. Injuries to the dominant lower extremity were also predominant in elite male Gaelic footballers (59%) (Newell et al., 2006) and in adolescent female soccer, (61%) (Le Gall et al., 2008), but presented with lower percentages than that observed in adolescent Ladies Gaelic footballers in the current study. Muscular strength and neuromuscular control imbalances, particularly during single limb loading activities such as kicking and jumping commonly observed in both Gaelic football and soccer, may be one contributing factor to the substantially greater difference in lower extremity injuries to the dominant and non-dominant limb (Hägglund & Waldén, 2016). As Gaelic football participation requires a substantial amount of single limb loading activities such as kicking to score and pass, soloing the ball while travelling, and jumping, muscular fatigue may also be a contributing factor to the high occurrence of dominant side lower extremity injuries, particularly as 73.3% of current participants reported primarily both kicking and jumping off the same limb.

The calf was the most commonly reported location of prospective injury in adolescent Ladies Gaelic football (30%), which was higher than reported in adolescent male Gaelic footballers (6.7%) (O'Connor et al., 2016) and collegiate male Gaelic footballers (5.6%) (O'Connor et al., 2017) and retrospectively in adolescent females participating in sports/PA in the current study (10.5%). Calf fatigue-related muscle disorders were the most commonly reported injury in Ladies Gaelic football, which may be a resulting factor of higher training loads observed in injured participants, and potentially poor recovery protocols, lack of sufficient warm-ups/ cool-downs (O'Sullivan et al., 2009), stretching and flexibility programmes (Hägglund et al., 2013) and varying or poor playing surfaces (Cromwell et al., 2000). The significant small association ($p= 0.003$; $\varphi= 0.30$) between a player with mean training loads greater than the total mean weekly training loads and injury occurrence may be a contributing factor to the high incidence of fatigue induced

muscular injuries, in conjunction with poor or non-existent recovery strategies. Further research on the factors contributing to fatigue-related injuries may assist in the development of targeted training, warm-up and injury prevention practices in Ladies Gaelic football.

Knee injuries were one of the most commonly reported prospective (20%) and retrospective (26.3%) injuries in adolescent Ladies Gaelic footballers, with similar results observed in senior club level (10.2%; 18.8%) Ladies Gaelic football (Brown et al., 2013; Crowley et al., 2011), adolescent male Gaelic footballers (18.7%) (O'Connor et al., 2016) and adolescent female soccer (25.0%) (Clausen et al., 2014). Different neuromuscular, hormonal and mechanical risk factors may increase the risk of knee injuries in adolescent females compared to their male counterparts (Ingram et al., 2008). Hormones such as estrogen, progesterone and relaxin fluctuating during the menstrual cycle have been associated with decreased neuromuscular control and increased ligament laxity resulting in a reduction in passive and active stability around the female knee (Hewett et al., 2000). Neuromuscular differences in females compared to their male counterparts include; decreased stiffness, proprioceptive deficits, decreased potential for dynamic stabilisation, co-ordination imbalances in conjunction to commonly observed imbalances in lower extremity recruitment pattern imbalances, strength imbalances and aberrant timing of activation control around the knee joint (Henry & Kaeding, 2001). Additional anatomical differences between females and males also contribute to the increased risk of injury in females, with higher Q-angles, the femoral notch size and shape and mal-alignments such as excessive foot pronation and increased femoral anteversion at the hip and genu valgus at the knee (Dugan, 2005). Three-quarters (n= 3) of knee injuries reported in adolescent Ladies Gaelic footballers were overuse in nature, with half (n= 2) of knee injuries specifically reported as patellar tendinopathies. Players' muscular flexibility (Witvrouw et al., 2001), activity loads (Malliaras & O'Neill, 2017) and altered biomechanics (Malliaras & O'Neill, 2017) have all been associated with the occurrence of patellar tendinopathies. Further investigations into the effects of Gaelic football playing demands and patterns and players' biomechanics have on the risk of patellar tendinopathy should be completed to identify players at increased risk of sustaining a patellar tendinopathy. An increased priority into the inclusion of players' training load monitoring in any injury prevention programme must also be considered for adolescent Ladies Gaelic footballers in attempt to reduce the occurrence of overuse knee injuries through activity load monitoring, as recommended by Roe et al. (2017) in the Operational Framework for Managing Injury

Risk, which may be of particular benefit within adolescent Ladies Gaelic footballers as provisional results in the current study have demonstrated significantly higher training loads in injured participants. In addition, repeated jumping can result in vertical ground reaction forces up to four-times the players' body weight to be transferred through the knee joint (Louw et al., 2008). These repeated forces in conjunction with a developing adolescent neuromuscular control system, which may be unable to maintain knee stability, may result in excessive forces above the physiological threshold transmitted through the knee joint leading to injury within the knee joint structures (Louw et al., 2008). This may be one of the contributing factors to the high incidence of knee injuries within adolescent Gaelic games as Gaelic football requires repeated jumping to contest and catch the ball, as well as a high proportion of adolescent females reporting participating in basketball (12.4%) and camogie (10.3%), which also require repeated jumping.

Finger injuries were also commonly reported in both adolescent (10%) and senior club Ladies Gaelic footballers (22.5%) (Brown et al., 2013), with 10.5% of sports/PA injuries retrospectively reported in the current study also occurring to the fingers and an additional two finger injuries prospectively sustained in adolescent Ladies Gaelic footballers while participating in school competition. Injuries to the hand/fingers as one of the most commonly reported injuries is unique to Ladies Gaelic football, as no upper extremity injuries were reported in the three most commonly reported injuries for adolescent (O'Connor et al., 2016), collegiate (O'Connor et al., 2017), or senior elite male Gaelic football injuries (Murphy et al., 2014; Newell et al., 2006; Cromwell et al., 2000). Finger sprains specifically were the joint third most common injury reported in adolescent Ladies Gaelic footballers, accounting for 10% (n= 2) of injuries. The high frequency of ball to hand or finger contacts during Ladies Gaelic football while catching, tackling and hand-passing the ball, in particular, may be contributing to the high incidence of hand/ fingers injuries. Greater levels of finger and hand injuries in Ladies Gaelic football compared to male Gaelic football may be as a result smaller and weaker hands particularly in adolescent females compared to males (Brown et al., 2013), where females use the same size 4 football from U-12 to senior and males use the same size 4 football up until U-15 where they progress to the bigger and heavier size 5 football. A reduction in either the weight or the size of the Ladies Gaelic football, particularly for underage adolescent players may assist in the reduction of hand and finger injuries, similar to the provisional results found in adolescent female soccer where a lighter and smaller ball resulted in 22% lower acute match injury incidence rate risk compared to the control group with a

standard ball (Zebis et al., 2018). The introduction of hand and finger protective equipment into Gaelic football gloves, similar to that of goalkeeper gloves, may also assist with the reduction of hand and finger injuries in Ladies Gaelic football. Additionally, prioritising the teaching and implementation of proper catching and blocking techniques may also lead to the reduction of hand and finger injuries as all finger injuries were as a result of contact with the ball.

Non-contact mechanisms of injury were commonly observed in adolescent Ladies Gaelic football (65%), which is expected as a result of the reduced physical contact permitted by the rules of Ladies Gaelic football (Brown et al., 2013). Running mechanisms of injury accounted for approximately one-third of injuries (n= 7) in adolescent Ladies Gaelic football and similarly sprinting was a common mechanism of injury reported in adolescent male Gaelic football (25.7%) (O'Connor et al., 2016) and collegiate Gaelic football (24.8%). Future research should focus on the effects of current IPPs focused on reducing non-contact lower extremity injuries on adolescent Ladies Gaelic football as no examination has been completed to date. IPPs may also be beneficial financially for the club, players, players' parents and the Ladies Gaelic football organising body long-term, as an investment into the development of IPP, assessment of the IPP in real-world settings, dispersion of information and training of coaches may lead to the uptake and adherence of IPPs with teams and the reduction of injury risk and the financial burden associated with injury. The high proportion of running and gradual onset mechanisms of injury reported may be associated with the high proportion of fatigue-induced muscle disorders reported and the onset of fatigue, as muscular fatigue while running can lead to delayed muscle activations and alterations in kinematic and kinetic aspects of running stride mechanics (Gerlach et al., 2005), all of which may alter a players' risk of injury. Large distances were covered by both adolescent male Gaelic footballers with a mean distance of 5,732 (± 1,047) meters per match (Reilly et al., 2015) and in senior elite male Gaelic footballers with a mean match distance covered of 8160 ± 1482 (Malone et al., 2016). These large distances covered by elite male Gaelic football midfielders, half-backs and half-forwards particularly, decreased by up to 11.0% during the second half of games (Malone et al., 2016), highlighting the large distances covered by players and the implications fatigue may have on playing performance. To counteract the effects that fatigue may have on injury incidence, the inclusion of rolling substitution or an increase in the amount of substitution allowed per game may assist in the reduction of fatigue-related injuries. As previously highlighted with the high occurrence of calf fatigue-induced

muscle disorders, playing surfaces (Cromwell et al., 2000), flexibility levels (Hägglund et al., 2013) and player recovery protocols (Green & Pizzari, 2017) may also be contributing to the fatigued state in conjunction with the large distances covered while participating. In combination with implementing training sessions that specifically mimic the physiological match demands of Gaelic football, coaches must also consider player recovery and muscular strengthening to counteract the implications of fatigue while running. Further investigations into the physiological demands of Ladies Gaelic football and in particular adolescent Ladies Gaelic football may also assist in the development of specific training programmes in an attempt to combat the effects fatigue has on both performance and injury risk. One-quarter of injuries in adolescent Ladies Gaelic football were as a result of contact with another player, which also accounted for one-third of injury mechanisms reported within senior elite male Gaelic football (Murphy et al., 2014). The nature of Gaelic football may contribute to the incidence of contact injuries as it requires players to continuously contest for possession and are required to be in close contact with each other while playing or attempting to play the ball; contesting for the ball, tackling, blocking, passing, shadowing, soloing and shooting.

Injuries during matches predominantly occurred during the second half (46.2%) and specifically, 38.5% of injuries occurred in the final quarter in adolescent Ladies Gaelic football. This increased injury incidence in the final quarter of a match has previously been identified in adolescent males (36.0%) (O'Connor et al., 2016) and collegiate males (48.5%) (O'Connor et al., 2017) and may be as a result of an increase in intensity towards the end of a match in order to achieve a win or as a result of player fatigue (Wilson et al., 2007; O'Connor et al., 2016). In an attempt to reduce the injury incidence towards the end of matches and as a result of fatigue, dividing the match into four quarters and the introduction of rolling substations may provide players with more frequent recovery periods to reduce the build-up of fatigue (Wilson et al., 2007) particularly in younger players. In addition, the implementation of specific training programmes to incorporate the development of players' lower body strength, repeat sprint ability and sprint speed may also contribute to the reduction of injuries (Malone et al., 2018). While the majority of injuries in adolescent Ladies Gaelic football occurred in backs and forwards, no significant differences were observed between outfield playing positions, which was also noted in club level Ladies Gaelic footballers (Brown et al., 2013). The absence of injuries to goalkeepers observed within the current study, compared to male adolescent (16.0%)

(O'Connor et al., 2016) and secondary school (6.5%) (Watson, 1996) Gaelic footballers may be as a result of the low proportion of goalkeepers analysed in this study (n= 4).

3.5.3 Injury Outcome

The majority of injuries in adolescent Ladies Gaelic footballers were minor (85%), accounting for a greater proportion of injuries compared with adolescent male Gaelic footballers (41.7%) (O'Connor et al., 2016). Differences in playing style and rules in Ladies Gaelic football compared to male Gaelic football, in particular, the fact that shoulder charges and deliberate body contact while contesting for the ball are not permitted (Brown et al., 2013) may have contributed to the greater proportion of minor injuries reported in adolescent Ladies Gaelic football. Minor injuries (49.1%) also accounted for the majority of injuries retrospectively reported in the previous 12-months while participating in sports/PA. The predominance of minor injuries in adolescent females, both in Ladies Gaelic football and all sports and PA participation, may be affected by the injury severity definition related to time lost in place of structural damage sustained, as players may have continued to participate despite being injured. Additionally, players may simply have received an injury in a location which allowed them to continue to participate, with or without a restriction in performance.

The sole concussion reported prospectively in club level adolescent Ladies Gaelic football resulted in a participation time loss of 10.0 days, this however is shorter than that recommended by the LGFA and GAA where a minimum rest period of two weeks post-concussion followed by approximately one week of return to play rehabilitation is advised (GAA & UMPC Beacon Hospital amended by LGFA, 2015). Although there are current strategies in place to educate players, coaches and parents on concussion, further efforts may be required particularly at club underage levels to highlight the importance of following the return to play guidelines and potential implications to early participation or participation while symptomatic. Although the calf and knee were the most common locations of injury in adolescent Ladies Gaelic footballers, they had some of the lowest time loss burdens, with a mean of 1.7 and 1.0 days lost respectively, from Ladies Gaelic football participation. As a result of the majority of calf injuries being fatigue-induced muscle disorders and knee injuries being overuse, minimal time loss was reported with commonly only altered performance reported. All knee overuse injuries (n= 3) reported no time lost with participants continuing to participate while injured and with calf fatigue-induced muscle disorders 80% (n= 4) of participants reported no time lost but altered

performance as a result of their injury. In comparison all sports/ PA retrospectively reported, concussions (n= 2) and calf injuries (n= 6) had the greatest mean time lost burden, 44.0 and 38.7 days, greater than the majority reported in Ladies Gaelic football. The greater extent of time lost observed retrospectively in comparison to prospectively, may be related to the greater exposure time for data collected, the differing mechanisms of injury and physiological demands in other sports/PA exposing players to differing levels of injury risk. Additionally, data collected retrospectively was describing the most severe injury sustained in comparison to all injuries sustained in prospectively in Ladies Gaelic football which may have biased the results towards larger time loss burdens. No injuries in adolescent Ladies Gaelic football were classified as a severe injury (> 21 days lost) in comparison to 29.8% (n= 17) of injuries retrospectively reported, where by definition severe injuries resulted in greater time lost from participation.

Players feeling pressure to return to participation may also affect the severity classification of injuries, as a premature return to participation would affect the duration of time lost reported. The effects of an early return to participation or pressure to return may have affected injury severity reported in the current study as for the most severe sports and PA injuries sustained in the previous 12 months, approximately one-third of participant felt they prematurely returned to participation and one-third of participants felt pressure to return to participation, particularly from themselves. Further investigations into the motivations of adolescent players to continue participating while injured and the self-sources of pressure to return to participation may be warranted to reduce the high rates of recurrent injuries, through the development of targeted educational programmes for players. Furthermore, the predominance of minor injuries may be related to the relatively short data collection period in the current study compared to previous research in adolescent male Gaelic footballers (O'Connor et al., 2016), where naturally the occurrence of more severe injuries are rare and may not have occurred during the limited time frame. Also as a result of the short data collection period, the presence of severe injuries such as fractures, dislocations etc. were limited, and so only one X-ray was required during the study. In comparison, further investigations were required for 35.1% of injuries retrospectively reported in sports/PA. The data collected relating to sports and PA injuries retrospectively required adolescent females to describe the most severe injury sustained, which may have biased the results towards greater levels of further investigations and treatment, as severe injuries typically require more investigations and treatment than minor injuries. No surgical interventions were reported in adolescent

Ladies Gaelic football, in comparison to 6.7% of adolescent male Gaelic footballers (O'Connor et al., 2016) and 12% of collegiate male Gaelic footballers (O'Connor et al., 2017), potentially due to the shorter data collection period and limited severe injuries reported.

Of the players who retrospectively reported completing rehabilitation for their injury (45.6%), approximately one-fourth of those felt as though they had not completed an adequate level of rehabilitation prior to return to participation. The low proportion of players completing adequate rehabilitation may be contributing to the presence of recurrent (25%) and persistent injuries (5 %) prospectively observed in adolescent Ladies Gaelic footballers. Educational interventions for players, parents and coaches highlighting the importance of treatment and the completion and adherence to rehabilitation for musculoskeletal injuries attempting to reduce the risk of re-injury and improve performance, may assist with reducing the rate of recurrent and persistent injuries observed. Although one-third of adolescent Ladies Gaelic football players prospectively reported receiving treatment for their injury, this finding may have been affected by the injury assessment process completed in this study as players were advised to undergo treatment if it was required. The low proportion of adolescent Ladies Gaelic footballers receiving treatment for their injury may also be related to the high frequency of minor injuries and that only 40% of injuries resulting in more than 24 hours' time lost from participation.

3.5.4 Training Loads

The total mean weekly training loads reported in adolescent Ladies Gaelic footballers, 1,065.00 AU, was lower than that observed for elite senior male Gaelic footballers who reported a mean early in-season of 2,740 ± 610 AU and late in-season of 2,560 ± 603 AU (Malone et al., 2017 b). The differences in age and playing level of the elite senior male Gaelic footballers would contribute to the differences observed, where the senior elite males may be participating in a more structured training schedule which may also include strength and conditioning gym sessions and recovery sessions in addition to the traditional pitch training sessions.

Adolescent Ladies Gaelic footballers participating solely in Ladies Gaelic football had significantly lower ($p= 0.001$; $d= -.063$) mean weekly training loads than players participating in multiple sports/PA, with players participating on additional club teams

outside of their designated age category also presenting with significantly higher ($p < 0.001$; $d = 0.68$) mean weekly training loads when compared to players participating at only their designated age category. The monitoring of training loads for adolescent players, particularly players participating with multiple club teams and multiple sports/PA may be of specific interest within adolescent Ladies Gaelic footballers as injured participants reported a 27.5% higher mean training loads compared to uninjured participants. A significant ($p = 0.003$; $\varphi = 0.30$) association between training loads greater than the total weekly training load mean and injury occurrence was also found in adolescent Ladies Gaelic footballers. Similar results were found in elite senior male rugby league players were a significant association ($p \leq 0.01$; $r = 0.82$) between training loads and injury occurrence were found (Gabbett & Jenkins, 2011). This association between higher training loads than the total mean and injury occurrence highlights the importance of monitoring training loads for adolescent Ladies Gaelic football as an injury prevention strategy.

Acute changes in training loads have previously been associated with an increased risk of injury (Jones et al., 2017). Weekly changes in training loads of ≥ 1,000 AU in amateur hurlers and elite Gaelic footballers resulted in approximately 2.5 and 5 times greater risk of injury compared to the reference group with changes of <120 AU (Malone et al., 2018; Malone et al., 2017 b). Although not at a specific threshold, these acute changes in training loads have also been identified in adolescent Ladies Gaelic football, where training loads in two-thirds of injured players investigated in the week prior to injury were greater than the individual player's mean. These acute changes in training loads may increase a participants' risk of injury as increased physical loading is placed on the player, which may not be physically tolerated by the musculoskeletal system resulting in an increased risk of injury (Jones et al., 2017). The acute increase in training loads may also result in an increase in player fatigue, which has previously been discussed as increasing a players' risk of injury as there are alterations in muscle recruitment and biomechanical alterations and compensations. Further investigation into the threshold of acute changes within adolescent Ladies Gaelic football weekly training loads would assist with regulating player's loads as part of injury prevention measures and also to identify the different training tolerance thresholds between female and male Gaelic footballers and also adult and adolescent athletes.

Although the current study indicates a significant association between injury occurrence and higher training loads, the data presented is limited due to the small sample of injured participants and incomplete continuous training load data available for injured participants. However, further research into the association between training loads and injury occurrence in Ladies Gaelic football and investigating the training-injury prevention paradox and the protective effects of training loads would be beneficial

3.5.5 Limitations

Only U-14 and U-16 club Ladies Gaelic football teams were included in this study. Therefore, further research is required for both younger and older club Ladies Gaelic footballers and on elite senior Ladies Gaelic footballers. In addition, data collection periods were limited in duration in this study due to the short knock-out style of play adopted for U-16 Ladies Gaelic football to accommodate players completing state examinations. Furthermore, many U-16 teams had already begun participation in competitions at the start of data collection, limiting the data collected regarding pre-season training loads endured by adolescent Ladies Gaelic footballers. The limited data collection periods may also have caused a certain amount of bias towards minor injuries as longer exposures are typically required to observe more severe and overuse injuries. Future research should focus on longer data collection periods including the pre-season to identify the full effects of training and competition peaks on injuries, as well as greater lengths of exposure to the risk of injury. The poor completion rates of the weekly training logs is another limitation observed in the current study for both exposure rates and training loads. The variations in training attendance, potentially because of players participating in multiple sports/PA and on multiple teams which caused clashes in training and match schedules, resulted in gaps in training load data collected. The missing training and match exposures were estimated using the mode of completed responses, which may be over or under-estimating the true exposures. Future research may investigate the use of different methods for training load data collection such as phone applications or text messaging systems where participants can submit their training exposures remotely or on a more frequent basis to reduce the effects of recall bias and the omission of exposures due to players forgetting their training from the previous week as collected in the current study.

3.6 Conclusion

Less than one-sixth of all adolescent Ladies Gaelic footballers sustained an injury throughout the duration of the study, with greater injury rates in U-16 players than in U-14 players. Match injuries accounted for triple the number of training injuries, where U-16 players had a significantly higher match injury incidence than the younger U-14 players. Over one-third of injuries reported resulted in time lost greater than twenty-four hours, where acute and new injury onsets were predominant. Injuries to the lower extremity accounted for just under three-quarters of injuries reported, with the calf the most common location of injury. Calf fatigue-induced muscle disorders were the most commonly reported injury in adolescent Ladies Gaelic footballers, while minor injuries were predominant overall. Although future research is required, Ladies Gaelic football injury incidence increases with an increase in age and during match participation. Future training and injury prevention recommendations specific to injury patterns identified in adolescent Ladies Gaelic footballers should be developed to assist with reducing the risk of injury with an increase in age and intensity during match play. Higher training loads were associated with the occurrence of an injury however, further research is required to fully assess the training-injury prevention paradox and the relationships between varying levels of training loads and injury occurrences.

Chapter 4

Coaches' Attitude towards Injury Prevention in Ladies Gaelic Football

4.1 Abstract

Background: Injury occurrence or the fear of injury occurrence is a leading cause of adolescents dropping out of sports and PA participation annually. To counteract this, injury prevention programmes (IPP) have been developed. However, while research has shown IPP to be effective, their implementation remains low. Investigating coaches' current implementation rates and potential barriers to the implementation of IPPs may assist with future planning and distribution of IPPs in Ladies Gaelic football.

Aim: This aim of this study is to identify Ladies Gaelic football coaches' current implementation practices, perception, experience and willingness to implement IPPs.

Methodology: An online survey was developed according to the theory of planned behaviour and adapted from previous research and validated using a three-round Delphi review process using a panel of experts (n=5). Data was collected from current Ladies Gaelic football coaches over 18 years old with a minimum of one seasons' experience, using the online survey development website SurveyMonkey Inc. (San Mateo, California, USA) between March and April 2018. Recruitment was primarily conducted via social media and direct contact with clubs and organising bodies.

Results: One hundred and eighty-four responses (females n= 101, male n= 83, mean age= 38.0 ± 11.0 years, mean coaching experience= 6.21 ± 4.76 years) were included for analysis after screening for completion and inclusion criteria of 466 total responses. Over 78% of coaches were currently unaware of any IPPs and 47.8% of coaches reported using an element of injury prevention with their team. Lack of coach knowledge and information regarding IPP (81.5%) was the main barrier identified to IPP implementation. Significantly lower levels of ability to implement an IPP were observed in club compared to county level ($p= 0.014$; $d= 0.83$) and in underage compared to adult level ($p= 0.001$; $d= 0.77$) coaches. Coaches who held a Gaelic games coaching certification displayed significantly better attitudes ($p= 0.019$; $d= 0.60$), willingness ($p< 0.001$; $d= 1.16$) and perceived ability ($p= 0.002$; $d= 0.85$) towards injury prevention. A small percentage of coaches (13.6%) demonstrated a strong ability to implement an IPP.

Conclusion: Although willingness and attitude levels towards IPP were strong, a small percentage of coaches had a strong perceived ability level to implement an IPP. Future research should focus on improving coaches' ability and reducing barriers to IPP implementation.

4.2 Introduction

An increased focus has been placed on the risk of injury that occurs with participation in sports and PA (LaBella & Myer, 2017). This increased focus on the risk of injury is currently over shining the vast arrange of benefits associated with sports and PA participation; improved overall health and bone density, lower rates of obesity/overweight, reductions in cardiovascular disease, diabetes, risk-taking behaviours and depression and enhanced self-esteem and peer socialisation, all of which outweigh the risk of injury (LaBella & Myer, 2017). Injury prevention is a critically important issue to healthcare provision and in the promotion of health and wellness, however, an inconsistency between the amount of research in the area and the public health burden of injuries exists (Emery, 2010). Future research into injury prevention strategies is vital to establish the best practices for implementing injury prevention for healthcare professionals, sports and health administrator and organisations, policymakers, the participants themselves, coaches, parents and the public in general (Emery, 2010). Numerous disparities between injury prevention research and implementation have hindered previous injury prevention efforts including; adapting successful research into practical real-world applications, to ensure information is dispersed to the desired people to have a population effect and to translate the development and controlled testing of an IPP to wide-scale dispersion and adoption (Hanson et al., 2014; Hanson et al., 2012). These discrepancies arise from the conflicting approaches that researchers, policymakers, medical professional and the community, including coaches, take to the all the implementation challenges posed by the related complexity of injury and injury prevention (Hanson et al., 2014). Coaches' knowledge and attitude towards injury prevention practices is a commonly reported influencing factor that affects the acceptance and implementation of IPPs (Norcross et al., 2016).

IPPs have been developed to reduce injuries specific to Gaelic footballers and include the GAA 15 and the Activate GAA warm up. The GAA 15 was found to have a lower injury incidence when compared to a control group (2.62 vs 7.62 injuries per 1,000 hours' exposure) in college-level Gaelic footballers and hurlers (Schlingermann et al., 2017) as well as a 45% reduction in lower extremity injuries in adolescent hurlers (Kelly et al., 2017). Although previous research has shown the benefits of the GAA 15, only 7.7% of coaches in male Gaelic football reported using the GAA 15 irrelevant of the wide-scale acceptance of the proposed benefits of implementation (Reilly & Kipps, 2017). While

research has shown that coaches are willing to support the inclusion of injury prevention programmes and recognise their value, they often report a lack of knowledge and feel unequipped to implement preventative programmes (Twomey et al., 2015). In addition, to maximise the effectiveness of injury prevention strategies, they should be tailored to the playing experience, level and age of coaches and players to account for different baseline levels of injury risk knowledge and injury prevention beliefs (McKay et al., 2014).

Although previous research has investigated the understanding and perception of injury prevention with male Gaelic football coaches and in other sports, to the author's knowledge, no research has examined the willingness to participate or current participation levels in Ladies Gaelic football has been reported for either of the above-mentioned Gaelic games specific IPPs or any IPP. As a result, the aim of this study is to investigate Ladies Gaelic football coaches' attitudes towards IPPs, including their attitude towards, ability to, understanding of and willingness toward injury prevention.

4.3 Methodology

4.3.1 Study Design

A mixed method survey design was adopted using a variety of quantitative and qualitative questions and responses. An online survey using the online survey development cloud-based software SurveyMonkey Inc. (San Mateo, California, USA) was used to gather responses.

4.3.2 Survey Development and Delphi Validation

The online survey was developed using previous research that investigated the relationships between high school coaches' beliefs about sports injury and IPP readiness (Jang, 2013), the effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer (McKay et al., 2014) and the factors influencing high school coaches' adoption of IPPs (Norcross et al., 2016), and by following the theory of planned behaviour (TPB). The TPB aspects included in the online survey were; attitude, subjective norm and perceived behavioural control (PBC). Attitudes were defined as whether the coach was in favour of IPPs and measured by; attitudes towards IPP and willingness to implement an IPP. Subjective norm was defined by how much the coach felt social pressure to implement an IPP and measure using; coaches understanding of current IPP use and PBC was defined by whether the coach felt in control to implement an IPP and was measured by; their perception of their current ability to implement an IPP.

The Delphi validation process was conducted using the Benhamou et al. (2013) protocol, where three review rounds were completed. A panel of experts from the field of injury prevention and injuries were recruited to participate in the Delphi validation review. Eight experts took part in the first round and five experts participated in rounds two and three due to drop-out (Figure 4.1). For each of the rounds of the Delphi validation review process, the panel of experts was allocated two weeks to complete their review and were contacted by email. In the initial and second round of review each expert on the panel was asked to review each question and answers within the survey and rate each question on an 11-point Likert scales (0- disagree to 10- agree) on two scales; selection in the final questionnaire and agreement with the question formulation. Additionally, where an expert disagreed with the formulation of a question they were encouraged to propose a new formulation and experts were also invited to suggest any additional questions or areas

of relevance. After the first and second round of reviews respectively the median score from the Likert scale ranking for each question individually, where a median score ≤7 for round one and ≤8 for round two resulted in the exclusion or amendment of a question and answer. Experts' comments were also recorded and analysed for inclusion in the amended survey for the following round. For the final and third round of the review process, the experts were asked for their consensus towards the validation of the survey and given the opportunity to provide any comments regarding the survey as a whole. Survey consensus was achieved during the third round of the review process.

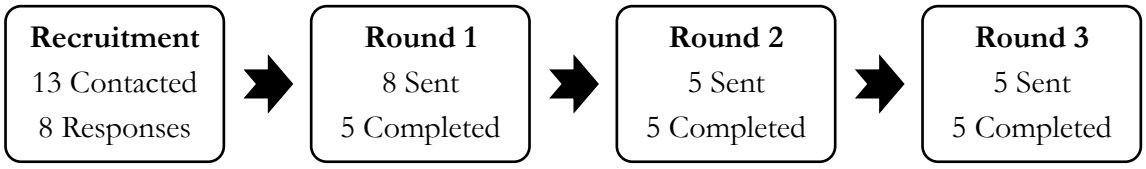

Figure 4.1: Delphi Validation Expert Panel Response Rate

The initial draft of the survey submitted for round 1 of the Delphi review process contained 46 questions in three specified sections (Table 4.1). After the first round of the Delphi validation review, an additional seven questions were included, which were as a result of separating and specifying pre-existing questions, the addition of three questions, and dividing the survey into seven sections. The majority of amendments to the survey between round 1 and round 2 of the Delphi validation review, involved the rephrasing and rewording of both questions and the pre-set answers. In the final draft of the survey (Appendix F), one additional question was included from draft 2 and the inclusion of a definition for injury prevention to assist in the clarification of data collected. Amendments were also made to the wording of questions and answers as recommended by the panel of experts.

Table 4.1: Survey Changes throughout the Delphi Validation Review

	Draft 1- Round 1 of Delphi Review	Draft 2- Round 2 of Delphi Review	Draft 3- Round 3 of Delphi Review
Number of Questions	46	53	54
Number of Sections	3	7	7
Section Names	1) Coaching Background 2) Injuries 3) Injury Prevention	1) Participant Information 2) Coaching Background 3) Injuries 4) Injury Prevention 5) Warm-Up 6) Cool-Down 7) Additional Comments	1) Participant Information 2) Coaching Background 3) Injuries 4) Injury Prevention 5) Warm-Up 6) Cool-Down 7) Additional Comments

4.3.3 Survey Participants and Data Collection

A non-probability volunteer sample was recruited for participation in the online survey, where participants volunteered to participate in the survey of their own accord. Participant recruitment was conducted using online social media advertisements, direct electronic invitations to clubs and Ladies Gaelic football organisations via email and the use of recruitment posters, all outlining the inclusion criteria and the link to survey (Appendix H). Inclusion criteria for participation in the online survey were current Ladies Gaelic football coaches of any level or age category, over 18 years old and with a minimum of one season experience coaching in Ladies Gaelic football. Consent for participation was collected at the beginning of the online survey where participants were asked to choose to either agree or disagree to participation, after the study information was presented including an outline of the study aims, inclusion criteria, potential risks or benefits to participation and contact details for the study investigators (Appendix G). Ethical approval was received for this study from the Athlone Institute of Technology Research Ethics Committee in December 2017.

The survey was published online using the SurveyMonkey Inc. (San Mateo, California, USA) website, where participants access the survey using a specific link (surveymonkey.com/r/AITCPIP). The total number of responses was 466 and once the responses were screened for completion and meeting the inclusion criteria 184 responses were included for analysis, with a completion rate of 39.5%. Data was collected online on

SurveyMonkey Inc. (San Mateo, California, USA) from 21st March to 30th April 2018. It was possible for participants to cease their survey response at any point and to continue at a future time using the same device. There were no time restrictions on the response durations, however, there was a limit of one survey response per participant. As the there was a completion rate of 39.5%, the typical time spent engaging with the survey was 6 minutes.

4.3.4 Data Analysis

The data collected was downloaded directly from SurveyMonkey Inc. (San Mateo, California, USA) in both Microsoft Excel 2016 and IBM Corp. Released 2016 IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp) format. All responses were screened for completeness and meeting the inclusion criteria. Once the data were screened, the descriptive analysis for each individual question was completed. Frequencies and distributions of responses were analysed using IBM Corp. Released 2016 IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp) and visual representation of results was completed using Microsoft Excel 2016. The total levels of willingness to, ability to and attitudes towards injury prevention were calculated by ranking each pre-set response i.e. strongly agree/ very likely= 5, agree/ likely= 4, neither agree/ disagree= 3, disagree/ unlikely= 2 or strongly disagree/ very unlikely= 1, and calculating the total response number from all questions in the section. Where statements were negatively phrased the rankings for the pre-set responses were adapted where strongly agree/ very likely= 1, agree/ likely= 2, neither agree/ disagree= 3, disagree/ unlikely= 4 or strongly disagree/ very unlikely= 5. Eight statements were included for analysis for coaches' attitude towards injury prevention giving a max score of 40, six statements were included for analysis for coaches' willingness to implement an injury prevention programme giving a max score of 30 and 11 statements were included for analysis of coaches' current perceived ability to implement an IPP giving a max score of 55. Higher scores indicated a more positive attitude towards injury prevention, greater willingness to implement an IPP or higher perceived ability to implement an IPP (Figure 4.2).

Significant mean differences between groups were analysed using the parametric independent t-tests at a significance level of $p \leq 0.05$. Independent t-tests were used to analyse difference in total attitude, willingness and perceived ability scores for; Completion of LGFA/GAA coaching certification (yes or no response), completion of

LGFA coaching certification only (yes or no response), gender (male or female) and coaches' history participating in GAA (yes or no). One-way ANOVA was used to analyse significance between the means or two or more independent (unrelated) groups, again at a significance level of $p \leq 0.05$. The one-way ANOVA was used to analyse difference in total attitude, willingness and perceived ability scores for; current level coached (club, county, club & county, college & school), years of coaching experience (1, 2-5, 6-10, 11-15, 16-20, 20+ years) current age category coached (underage, adult or both), current use of IPP (yes, no or unsure) and interest in further training and education (yes, no or unsure). Following the completion of the one-way ANOVA, post-hoc analysis was completed using the Tukey test. Effect sizes for differences between two means (independent t-tests and post-hoc analysis) were calculated using Cohen's d, where 0.2 was classified as a small effect, 0.5 as a medium effect and 0.8 as a large effect and the effect size for differences between more than two means (one-way ANOVA) were calculated using Eta (η) which analysed the association of dependent scale variable and independent categorical variables and was classified between 0- 1, where 1 was a high degree of association.

Correlations or the assessment of the relationship between two continuous scale variables were completed using the Pearson's Correlation (r) at a $p \leq 0.05$ significance level. The strength of the correlations was classified as; strong for r values of -1.0/ 1.0 to -0.5/ 0.5, moderate for r values of -0.5/ 0.5 to -0.3/ 0.3, weak for r values of -0.3/ 0.3 to -0.1/ 0.1 and very weak for r values between -0.1 to 0.1.

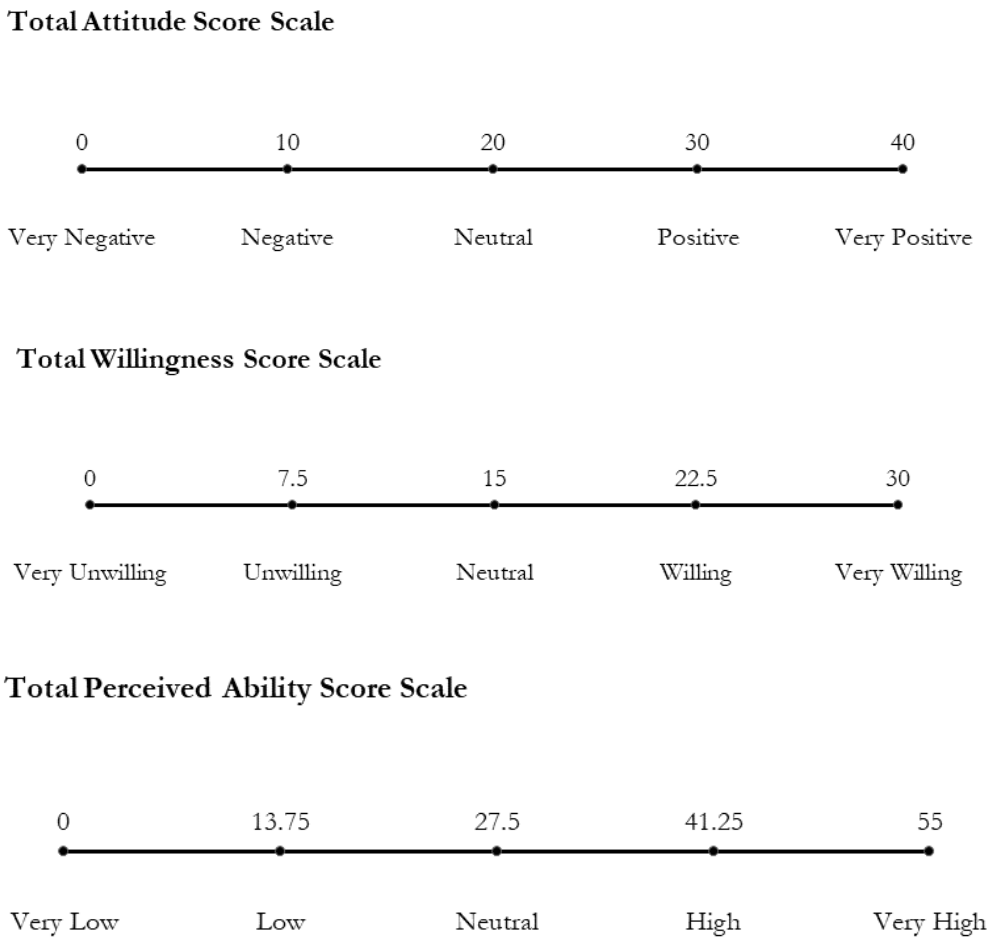

Figure 4.2: Attitude, Willingness and Perceived Ability Total Score Scales

4.4 Results

4.4.1 Participants

Responses of 184 coaches were analysed, from 101 females (54.9%) and 83 males (45.1%). The mean coach age was 38.0 ± 11.0 years with male coaches having a higher mean age (44.2 ± 8.1 years) than their female counterparts (32.9 ± 10.5 years). Most coaches (94.6%) reported previously playing Gaelic games, where over half of the coaches played Ladies Gaelic football (52.7%) and just under half participated in Gaelic football (46.7%). Participating at adult club (37.0%) and adult county (22.3%) were the most commonly reported highest levels that coaches participated at, with a small percentage of coaches reporting college/university level (9.8%) and inter-provincial level (9.2%) as their highest level of participation. The most common motives for participants to coach in Ladies Gaelic football are reported in Table 4.2, where wanting to contribute to the development of players and skills was reported by 69.6% of coaches as motives to coach.

Table 4.2: Motives for Coaching in Ladies Gaelic football

Motive	Number (n)	Percentage (%)
I wanted to contribute to the development of players and skills in Ladies Gaelic Football	128	69.6%
I enjoy the challenge of coaching	111	60.3%
I want to give back to my club/ the sport	94	51.5%
I want to stay involved in Gaelic Games	85	46.2%
I have a daughter playing Ladies Gaelic football	84	45.7%
I enjoy the excitement of competition	63	34.2%
No one else wanted to do it	38	20.7%
I was asked by the club to do it	14	7.6%

4.4.2 Coaching Experience and Qualifications

The mean experience coaching in Ladies Gaelic football was 6.21 ± 4.76 years, with males reporting a similar mean to females (males= 6.33 ± 4.57 years; females= 6.11 ± 4.94 years). The current percentage of coaches involved with each age category can be seen in Table 4.3 where some coaches may be coaching multiple age categories, with the majority coaching at underage. Just under half of the coaches (42.9%) reported currently coaching at more than one age category. Over half of coaches are currently coaching at underage club level (64.7%) and over a quarter of coaches also reported coaching at adult club (26.6%) level (Table 4.4). The highest level of coaching experience reported by Ladies

Gaelic football coaches can be observed in Table 4.5, where a small proportion of coaches coached an interprovincial Ladies Gaelic football team (3.3%) with most coaches reporting underage club as the highest level they have coached at (39.7%).

Table 4.3: Current Age-Categories Coached in Ladies Gaelic football Coaches

Age Category	Number (n)	Percentage (%)
U-6	8	4.3%
U-8	19	10.3%
U-10	34	18.5%
U-12	39	21.2%
U-14	50	27.2%
U-16	38	20.7%
U-18	46	25.0%
Junior	24	13.0%
Intermediate	11	6.0%
Senior	25	13.6%

Table 4.4: Current Levels Coached in Ladies Gaelic football Coaches

Level	Number (n)	Percentage (%)
Interprovincial	0	0.0%
Adult County	11	6.0%
College/University	5	2.7%
Adult Club	49	26.6%
Underage County	30	16.3%
Underage Club	119	64.7%
Secondary School	10	5.4%
Primary School	9	4.9%
Gaelic4Mothers	2	1.1%

Table 4.5: Highest Level of Ladies Gaelic football Coaching Reported

Level	Number (n)	Percentage (%)
Interprovincial	6	3.3
Adult County	14	7.6
College/University	5	2.7
Adult Club	40	21.7
Underage County	39	21.2
Underage Club	73	39.7
Secondary School	4	2.2
Primary School	3	1.6

Over one-third of coaches (34.2%) had completed a college or university degree and a further 27.2% of coaches completing postgraduate education. Coaches studying or working in medial, healthcare, sports science, physical education or high-performance roles accounted for 35.3% of all coaches. In addition to levels of education, 82.1% of coaches completed some level of first aid training and 92.9% of coaches completed a coaching certification course. First aid responder (52.2%) and occupational first aid (34.8%) were the most commonly reported type of first aid training within coaches, with a small percentage of coaches completing emergency medical technician (1.1%) and paramedic (0.5%) training (Table 4.6). Two-thirds (66.8%) of coaches reported completing the LGFA FUNdamental's coaching course with 38.0% of coaches reporting completing the LGFA Level 1 coaching course (Table 4.7). Most coaches (91.8%) completed either an LGFA or GAA coaching certification course. In addition to the Ladies Gaelic football specific coaching courses, just under half of the coaches reported completing the GAA foundation award course (47.3%), over a quarter completing the GAA award 1 coach education (26.6%) and 14.1% of coaches reported completing the FAI soccer kickstart 1 coaching course.

Table 4.6: First Aid Training in Ladies Gaelic football Coaches

First Aid Training	Number (n)	Percentage (%)
First Aid Responder	96	52.2%
Cardiac First Responder	58	31.5%
Occupational First Aid	64	34.8%
Emergency First Responder	24	13.0%
Emergency Medical Technician	2	1.1%
Paramedic	1	0.5%
Qualified Nurse	7	3.8%
None	33	17.9%

Table 4.7: Current coaching certifications completed by Ladies Gaelic football Coaches

Sport	Coaching Certification	Number (n)	Percentage (%)
Ladies Gaelic Football	LGFA FUNdamental's Course	123	66.8%
	LGFA Level 1	70	38.0%
Gaelic Games	GAA Foundation Award	87	47.3%
	GAA Award 1 Coach Education	49	26.6%
	GAA Award 2 Coach Education	18	9.8%
Soccer	FAI Kick Start 1	26	14.1%
	FAI Kick Start 2	11	6.0%
Rugby Union	IRFU- Mini Rugby	4	2.2%
	IRFU- Foundation Level	6	3.3%
	IRFU- Level 1	4	2.2%
	IRFU- Level 2	1	0.5%
None		13	7.1%
Other		16	8.7%

*LGFA- Ladies Gaelic football Association, GAA- Gaelic Athletic Association, FAI- Football Association of Ireland, IRFU- Irish Rugby Football Union

4.4.3 Injuries

The number of injuries sustained during the previous season reported by coaches, resulting in time lost from participation greater than 24 hours in Ladies Gaelic football for all age categories and levels showed that over two-thirds of teams sustained between 1 and 5-time loss injuries (Figure 4.3). One-fifth of all coaches (20.7%) reported more than six-time loss injuries sustained within their team in the previous season, with 12.0% of coaches reporting no injuries sustained. Over half of coaches reported that their current team does not have access to a medical or healthcare professional while participating in Ladies Gaelic football, with only 18.5% of teams having access during all participation. Irregular access to medical or healthcare professionals for players was reported by 43.0% of coaches, where access to matches only was reported by 10.9%, training sessions by only 1.1% and during some training sessions (12.0%) and some matches (19.0%) by coaches. In teams where medical or healthcare professionals are not available, 63.6% of coaches reported that the coaches themselves were responsible for conducting first aid if required, with assistant coaches/ selectors (41.8%) and parents (29.9%) also commonly reported (Table 4.8). Although 63.6% of coaches reported they were responsible for conducting first aid if required, just under half of the coaches

(45.1%) reported they rarely (once a year) conducted first aid, 21.2% sometimes (monthly) conducting first aid, 9.8% conducting first aid often (weekly) with an additional 23.9% reporting that they never conduct first aid while coaching.

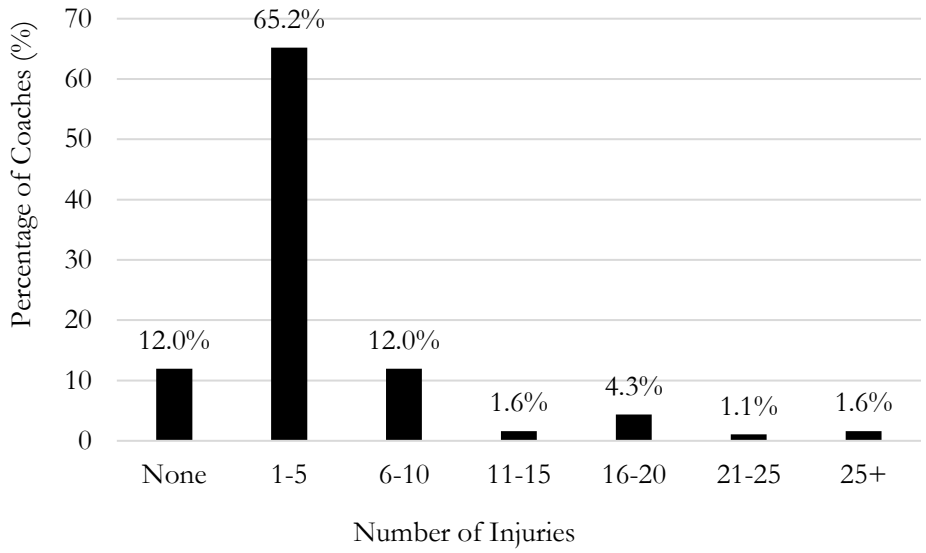

Figure 4.3: The number of injuries reported by coaches for the previous season

Table 4.8: First aid providers in clubs excluding medical and healthcare professionals

Level	Number (n)	Percentage (%)
Coach	117	63.6%
Assistant Coach/ Selector	77	41.8%
Parent	55	29.9%
Another Club Member	33	17.9%
Player	19	10.3%
Volunteer	16	8.7%
Spectator	10	5.4%
No One	3	1.6%
Female Liaison Officer	2	1.1%

4.4.4 Current Injury Prevention Knowledge and Practices

Over three-quarters, (78.3%) of coaches are currently unaware of any injury prevention programmes (IPP) in Gaelic games or any IPP in general. The most commonly reported IPP by Ladies Gaelic football coaches were; the GAA 15 (n= 28), the Activate GAA Warm-Up (n= 10), the FIFA 11/ FIFA 11+ (n= 4), PEP Warm-Up (n= 3) and the LGFA & SSC ACL IPP (n= 2). Although a large proportion of coaches are currently unaware

of any specific IPPs available, almost half (47.8%) of coaches reported conducting elements of injury prevention with their teams. Just over one-third of coaches (39.1%) reported not conducting an IPP with their team and the remaining 13.0% were unsure if IPP were conducted with their teams. From the 112 coaches who are currently or unsure if they are implementing an IPP (60.3%), the main motivations for implementing an IPP were; IPP doubles as a warm-up (75.0%), current research shows benefits (63.4%) and to improve team performance (46.4%) (Table 4.9).

Table 4.9: Coaches Motives for Implementing an Injury Prevention Programme

Motive	Number (n)	Percentage (%)
It doubles as a warm-up	84	75.0%
Current research shows benefits	71	63.4%
To improve team performance	52	46.4%
I observed elite/ high-performance teams participating in injury prevention programmes	27	24.1%
Advised to by medical and healthcare professionals	17	15.2%
Other teams/ coaches in the club have found it beneficial	17	15.2%
Due to high levels of injuries seen in previous seasons	16	14.3%
Players requested it	5	4.5%

Seventy-one percent of coaches reported that they were responsible for delivering the IPP to their teams (Table 4.10), where assistant coaches/ selectors (9.8%) and strength and conditioning coaches (7.1%) were also some of the most commonly reported. Over half of coaches reported conducting their IPP during every training session and match, approximately one-quarter of coaches reporting conducting their IPP during every training session with their current teams (Table 4.11). When looking at the time spent by coaches conducting IPPs during both training and matches the most commonly reported time spent was 6-10 minutes (42.0% and 38.4% respectively) with very few coaches spent greater than 20 minutes conductive IPP prior to either training (3.6%) or matches (0.9%) (Table 4.12).

Table 4.10: Person Responsible for Delivering Injury Prevention Programmes within Coaches current teams

Person	Number (n)	Percentage (%)
Coach	80	71.4%
Assistant Coach/ Selector	11	9.8%
Strength & Conditioning Coach	8	7.1%
Sports/ Exercise Scientist	3	2.7%
Medical/ Healthcare Professional	2	1.8%
Player/ Captain	0	0.0%
Any of the Above	5	4.5%
All of the Above	2	1.8%

Table 4.11: Frequency of Injury Prevention Programmes Implementation

Frequency	Number (n)	Percentage (%)
During every training session and match	64	57.1%
During every training session	27	24.1%
During one training session a week	9	8.0%
Other	5	4.5%
Once off/ pre-season screening and testing	3	2.7%
During every match	2	1.8%
Player self-administration outside of training/ matches	2	1.8%

Table 4.12: Duration of Time Spent Implementing Injury Prevention Programmes

Duration	Training		Match	
	Number (n)	Percentage (%)	Number (n)	Percentage (%)
None	1	0.9%	8	7.1%
1-5 minutes	14	12.5%	24	21.4%
6-10 minutes	47	42.0%	43	38.4%
11-15 minutes	35	31.3%	27	24.1%
16-20 minutes	8	7.1%	6	5.4%
20+ minutes	4	3.6%	1	0.9%
Other	3	2.7%	3	2.7%

The majority of coaches reported jumping and landing (87.5%) muscular activation (83.9%), change of direction (81.3%), running (80.4%) and dynamic balance (78.6%) elements in the current IPPs. Neuromuscular strengthening (45.5%) was also included in coaches' IPPs however to a less extent. Coaches reported sourcing their current IPP primarily from strength and conditioning coaches (44.6%), from other coaches (34.8%) and from currently available research (34.8%). A small proportion of coaches reported sourcing their current IPP from training coaches or workshops (4.5%) and from medical/healthcare professionals (8.9%) (Table 4.13).

Table 4.13: Coaches Sources for their Current Injury Prevention Programmes

Source	Number (n)	Percentage (%)
From current research	39	34.8%
Self-designed	30	26.8%
Provided by a Medical/Healthcare Professional	10	8.9%
Provided by a Strength & Conditioning Coach	50	44.6%
Saw it online/ on social media	30	26.8%
Training Course/ Workshop	5	4.5%
Other Coach	5	4.5%
Other	4	3.6%

4.4.5 Barriers to Injury Prevention Implementation

The most commonly reported barrier to IPP implementation reported by coaches was lack of knowledge/ information for coaches (81.5%). Lack of time during training sessions (42.9%) was also a commonly reported barrier, along with no access to equipment (28.3%), cost (21.7%) and lack of interest from players (16.3%).

4.4.6 Coaches' Attitude towards Injury Prevention

The mean total coaches' attitude towards injury prevention was 32.1 ± 4.0 (range 13-40), out of a possible 40. The majority of coaches had a positive attitude towards injury prevention, with 73.9% (n= 136) of coaches reporting total attitude scores above a score of 30. Coaches who completed a LGFA or GAA coaching certification course (mean= 32.43 ± 3.87) had strong significantly higher ($p= 0.019$; $d= 0.60$) attitudes towards injury prevention compared to coaches who completed other coaching certifications or no certifications (mean= 28.27 ± 3.26) (Figure 4.4). Coaches who reported currently using elements of injury prevention with their team (mean= 34.07 ± 3.70) also had a strong

significantly greater attitude levels compared to coaches who reported not using elements of injury prevention (mean= 30.25 ± 3.51; p< 0.001; d= 1.06) and coaches who were unsure if they were implementing elements of injury prevention with their team (mean= 31.06 ± 3.38; p< 0.001; d= 0.85). Gender (p= 0.502; d= 0.10), coaches previous Gaelic games playing experience (p= 0.820; d= 0.08), current level coached (p= 0.085; η= 0.190), current age category coached (p= 0.087; η= 0.163), coaching experience (p= 0.462; η= 0.235) and completing a LGFA coaching certification course (p= 0.360; d= 0.30) demonstrated no significant difference on coaches' attitude towards injury prevention.

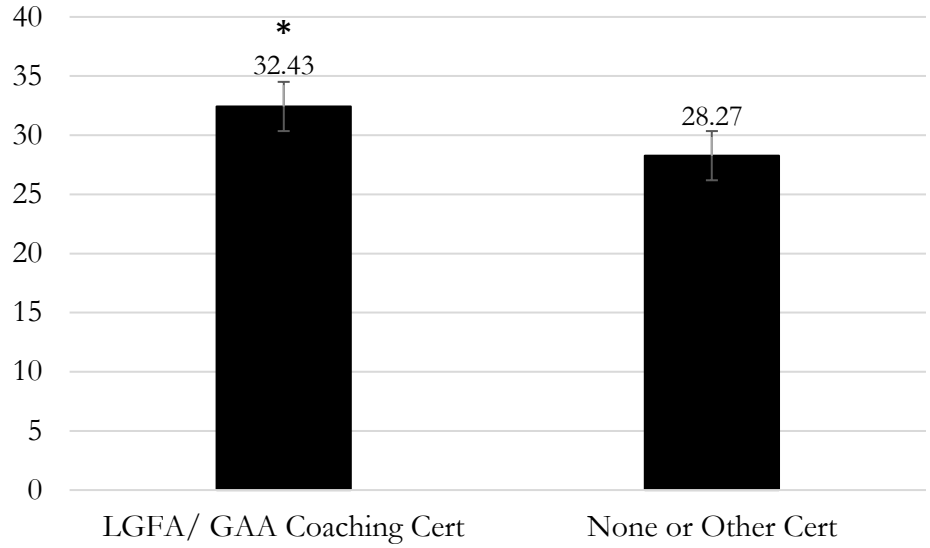

Figure 4.4: Total Attitude Scores and the effects of LGFA/GAA Coaching Certification, *significant at p< 0.05

Coaches current total attitude levels demonstrated a strong significant association with coaches perceived current total ability to implement an IPP (r= 0.555; p< 0.001) and with coaches' total willingness to implement an IPP (r= 0.650; p< 0.001). Very weak non-significant relationships between coaches' total attitude towards IPP and years' experience coaching in Ladies Gaelic football (r= 0.070; p= 0.347) and coach age (r= -0.010; p= 0.897) were observed.

The responses to questions surrounding coaches' attitudes towards injury prevention contributing to coaches' overall attitude towards injury prevention are represented in Table 4.14. Over two-thirds (68.5%) of coaches disagreed that IPPs take up too much precious training time, with a small majority of coaches feeling as though IPP would take up too much precious training time (7.1%). The majority (83.7%) of coaches also felt as though IPP would reduce the number of injuries sustained by their team and that injury

prevention is important during training sessions (92.4%). Over forty (40.2%) percent of coaches felt as though injuries were not an issue within their current team but agreed that it was important for both coaches (95.1%) and players (92.4%) to have current knowledge on IPPs. Forty -two percent of coaches neither agreed nor disagreed that IPPs cost too much money with only 11.9% of coaches agreeing.

Table 4.14: Distribution of Coaches' Attitude Responses towards Injury Prevention

Coaches' Attitude Towards Injury Prevention					
Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
IPPs take up too much precious training time away from necessary tasks	1.1%	6.0%	24.5%	47.8%	20.7%
I believe that using an IPP will reduce the number of injuries in my team	44.0%	39.7%	13.6%	1.6%	1.1%
The activities included in IPPs are relevant and beneficial to my players	46.7%	35.9%	15.2%	0.5%	1.6%
IPPs cost too much money	1.6%	10.3%	42.4%	25.5%	20.1%
Injury prevention is important during training sessions	60.3%	32.1%	6.5%	0.0%	1.1%
It is important for players to have current knowledge of IPPs	53.3%	39.1%	4.9%	0.5%	2.2%
It is important for coaches to have current knowledge of IPPs	63.6%	31.5%	2.7%	0.5%	1.6%
Injuries are an issue with my team	3.3%	24.5%	32.1%	31.5%	8.7%

4.4.7 Coaches' Understanding of Current Injury Prevention Programmes Practices

Over half (54.3%) of coaches disagreed that most Ladies Gaelic football teams are using IPPs compared to only 13.1% of coaches agreeing, and an additional 32.6% neither agreeing or disagreeing (Table 4.15). Most coaches (72.3%) however, disagreed that IPPs are solely for use with senior club teams or intercounty teams, where the majority of coaches (83.7%) also disagreed that IPPs should not be used with underage teams. Slightly more coaches disagreed (46.2%) than agreed (33.2%) that only adult teams are currently participating in IPPs. More Ladies Gaelic football coaches neither agreed nor disagreed (37.5%) that players are requesting to participate in IPPs than either agreeing (24.5%). The requirement of either a sports/ exercise scientist or a medical/ healthcare professional to implement an IPP is similarly disagreed with by coaches (44.6% & 46.2%), however over a third of coaches in both incidences also reported neither agreeing or disagreeing with the requirement of sports/ exercise scientists or medical/ healthcare professionals to implement an IPP.

Table 4.15: Distribution of Coaches' Understanding Responses of Current Injury Prevention Practices

Coaches' Understanding of Current Injury Prevention Practices					
Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Most Ladies Gaelic football coaches are using injury prevention programmes with their teams	2.2%	10.9%	32.6%	39.1%	15.2%
Injury prevention programmes are only for top-level senior club or intercountry teams	3.3%	9.2%	9.2%	31.0%	41.3%
Only adult teams are participating in injury prevention programmes	4.9%	28.3%	20.7%	32.6%	13.6%
Injury prevention programmes should not be used with underage teams	1.6%	3.3%	11.4%	40.2%	43.5%
Players are requesting to participate in injury prevention programmes	3.3%	21.2%	37.5%	31.0%	7.1%
Only teams with access to sports/ exercise scientists are participating in injury prevention programmes	2.7%	18.5%	34.2%	31.0%	13.6%
Only teams with access to medical/ healthcare professionals are participating in injury prevention programmes	2.2%	14.7%	37.0%	33.2%	13.0%

4.4.8 Coaches' Willingness to Implement an Injury Prevention Programme

Mean total coaches' willingness to implement an IPP scores were 23.2 ± 3.6, (range 11-30) out of a possible 30 reported. Over half of coaches were highly willing to participate in IPPs, with 57.6% of coaches reporting willingness scores above 23 and overall most coaches (98.9%) reported willingness to participate in IPP above 15. Coaches' current coaching level ($p< 0.001$; $\eta= 0.315$) and coaches current age category coached ($p= 0.015$; $\eta= 0.212$) had significant mean differences. Specifically, coaches currently coaching at county level (mean= 25.57 ± 2.89) had strong significantly higher willingness levels to implement an IPP compared to coaches currently coaching at club level (mean= 22.74 ± 3.47; $p= 0.003$; $d= 0.89$) and college or school level (mean= 21.70 ± 3.50; $p= 0.019$; $d= 1.21$) and coaches' currently coaching both club and county (mean= 25.12 ± 3.55) had moderate significantly higher willingness levels compared to club level alone (mean= 22.74 ± 3.47; $p= 0.038$; $d= 0.68$). Coaches currently coaching in adult age categories (mean= 24.68 ± 3.53) also demonstrated moderate significantly higher ($p= 0.018$; $d= 0.56$) willingness levels to implement an IPP compared to underage age categories (mean= 22.74 ± 3.44). Similar to attitude levels above, coaches who completed an LGFA or GAA coaching certification course (mean= 23.38 ± 3.60) had strong significantly greater ($p< 0.001$; $d= 1.16$) willingness levels to implement an IPP compared to coaches who had not completed a coaching certification course or completed a different coaching certification course (mean= 21.47 ± 2.70). Coaches who currently conducted elements of injury prevention with their team (mean= 25.20 ± 3.34) had strong significantly higher willingness to implement an IPP compared to coaches who were not implementing any elements of injury prevention (mean= 21.23 ± 2.96; $p< 0.001$; $d= 1.26$) or coaches who were unsure if they were implementing elements of injury prevention (mean= 22.61 ± 2.59; $p< 0.001$; $d= 0.82$). Gender ($p= 0.481$; $d= 0.10$), coaches previous Gaelic games playing experience ($p= 0.340$; $d= 0.30$), coaching experience ($p= 0.168$; $\eta= 0.352$) and completing a LGFA coaching certification course ($p= 0.856$; $d= 0.03$) demonstrated no significant difference on coaches' attitude towards injury prevention.

A weak significant relationship between coaches' years' experience coaching in Ladies Gaelic football and current willingness to implement an IPP was observed ($r= 0.172$; $p= 0.020$). In contrast, coaches current attitude towards IPP ($r= 0.650$; $p< 0.001$) and current perceived ability to implement an IPP ($r= 0.645$; $p< 0.001$) demonstrated a significantly strong relationship. A non-significant weak relationship between coaches' age and willingness to implement an IPP was observed ($r= 0.124$; $p= 0.92$).

Over 94% of Ladies Gaelic football coaches would be willing to implement an IPP if they were proven to show a lower chance injury occurrence and 87.5% of coaches would implement an IPP if proven to improve performance (Table 4.16). Approximately two-thirds of coaches also disagreed that they would not be willing to implement an IPP because they had not received specific training and 59.3% of coaches disagreed that their sessions were not long enough to implement an IPP. All coaches apart from 10.3% of coaches would be willing to change their current warm-up and training activities and 46.2% of coaches disagreed that they did not have anyone with the appropriate skills or knowledge to assist with the implementation of an IPP. Additionally, 80.5% of coaches disagreed than players are not willing to participate in IPPs and 76.1% of coaches also disagreed that it is the responsibility of a medical or healthcare professional or exercise professional to implement and IPP.

Table 4.16: Distribution of Coaches' Willingness Responses to Implement an Injury Prevention Programmes

Coaches' Willingness to Implement an Injury Prevention Programme					
Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I would be willing to include an injury prevention programme if it is shown to significantly lower the chance of injury occurrence	57.6%	37.0%	3.8%	1.1%	0.5%
I would implement an injury prevention programme if it was proven to improve player performance	51.1%	36.4%	9.2%	2.7%	0.5%
My team's training sessions are not long enough to devote time to injury prevention	1.6%	18.5%	20.7%	40.8%	18.5%
I am not willing to participate as I haven't received training in order to implement an injury prevention programme	3.3%	25.5%	17.9%	32.6%	20.7%
I am not willing to change the current warm-up and training activities that I am currently using	0.5%	2.7%	7.1%	47.3%	42.4%
I do not have access to anyone with the appropriate skills or knowledge to assist me with implementing an injury prevention programme	12.0%	26.6%	15.2%	28.8%	17.4%

4.4.9 Coaches' Current Perceived Ability to Implement an Injury Prevention Programme

The mean coaches' total perceived current ability to implement an IPP score was 37.4 ± 7.8 (range 20-55) out of a possible 55. Perceived ability scores less than 27 accounted for 10.3% of participant responses with 30.4% of coaches reported current ability to implement an IPP scores over 42. Gender ($p= 0.144$; $d= 0.22$), coaches previous Gaelic games playing experience ($p= 0.188$; $d= 0.52$) and completing a LGFA coaching certification course ($p= 0.271$; $d= 0.17$) demonstrated no significant difference on coaches' perceived ability to implement an injury prevention. Coaches' experience coaching in Ladies Gaelic football had a significantly higher perceived ability to implement an IPP ($p= 0.026$; $\eta= 0.437$), where coaches with 1 years' experience (mean= 30.83 ± 5.11) had strong significantly lower current ability to implement an IPP compared to coaches with 6-10 years coaching experience (mean= 38.25 ± 7.86; $p= 0.032$; $d= 1.12$) and coaches with 11-15 years coaching experience (mean= 40.06 ± 8.42; $p= 0.019$; $d= 1.32$). Coaches current coaching level ($p= 0.002$; $\eta= 0.278$) and current age category coached ($p= 0.001$; $\eta= 0.271$) as had significant higher means. Coaches currently coaching at county level (mean= 41.71 ± 5.29) had strong significantly higher current perceived ability ($p= 0.014$; $d= 0.83$) to implement an IPP compared to coaches currently coaching club level (mean= 36.33 ± 7.41) and coaches coaching at both club and county level (mean= 41.35 ± 9.14) had a significantly greater current perceived ability levels compared ($p= 0.050$; $d= 0.60$) to club level only. Coaches coaching at adult age categories (mean= 41.52 ± 6.77) had strong significantly higher mean current perceived ability levels to implement an IPP ($p= 0.001$; $d= 0.77$) compared to coaches coaching at underage age categories (mean= 36.02 ± 7.43). Coaches who completed an LGFA or GAA coaching certification course (mean= 37.84 ± 7.76) had a strong significantly greater ($p= 0.002$; $d= 0.85$) current perceived ability level to implement an IPP compared to coaches who did not complete a coaching certification or a different coaching certification course (mean= 31.87 ± 6.16). Similarly, coaches who are currently implementing elements of injury prevention with their team (mean= 43.07 ± 6.01) had strong significantly greater mean current perceived ability levels compared to coaches who are not implementing elements of injury prevention (mean= 43.07 ± 6.01; $p< 0.001$; $d= 1.95$) and compared to coaches who were unsure if they were implementing elements of injury prevention (mean= 35.16 ± 5.26; $p< 0.001$; $d= 1.40$).

A weak significant relationship between years coaching experience and perceived total current ability levels to implement an IPP were observed ($r= 0.184$; $p= 0.012$). A strong significant relationship between coaches perceived current total ability levels and attitude levels towards IPP ($r= 0.555$; $p< 0.001$) and between coaches' willingness to implement an IPP ($r= 0.645$; $p< 0.001$) were observed. Coaches' age had a non-significant very weak relationship with a coaches' perceived current ability to implement an IPP ($r= 0.065$; $p= 0.384$).

When looking at the individual responses contributing to the total coaches' current perceived ability to implement IPPs, 3.8% of coaches reported having issues from players about participating in IPPs and 4.8% of coaches reported having issues from players' parents or guardians regarding participation in IPPs (Table 4.17). Over one-tenth of coaches disagreed that they had the support from their club or county administration (12.5%) to implement an IPP with 29.3% of coaches disagreeing that they had adequate knowledge to explain the reasons and benefits to IPPs, 37.5% disagreed with having sufficient skills to implement an IPP and 42.4% disagreed with having sufficient knowledge to implement an IPP. Less than half of coaches agreed to having sufficient educational resources (43.5%), not having access to appropriate training equipment (35.3%), having sufficient use of facilities (49.5%) and not having sufficient experience to implement an IPP (48.4%).

Table 4.17: Distribution of Coaches' Current Ability Responses to Implement an Injury Prevention Programmes

Coaches' Current Ability to Implement an Injury Prevention Programme					
Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
I have the support of the club/ county administration to implement an injury prevention programme	17.4%	39.7%	30.4%	8.7%	3.8%
I have no issues or concerns from players' parents/ guardians about participation in injury prevention programmes	22.3%	50.5%	22.3%	4.3%	0.5%
I have no issues or concerns from players about participating in injury prevention programmes	23.9%	51.1%	21.2%	3.3%	0.5%
I have no problems getting my players to participate in injury prevention programmes	25.0%	43.5%	23.4%	8.2%	0.0%
I have sufficient educational resources available to me to assist with implementing an injury prevention programme	11.4%	32.1%	24.5%	25.5%	6.5%
I do not have access to appropriate training equipment to implement an injury prevention programme	6.0%	29.3%	24.5%	28.8%	11.4%
I have sufficient use of facilities to implement an injury prevention programme	10.9%	38.6%	21.2%	25.0%	4.3%
I have adequate knowledge to explain the benefits and reasons for participating in injury prevention	15.2%	39.1%	16.3%	23.9%	5.4%
I do not have sufficient experience conducting injury prevention programmes	8.2%	40.2%	14.1%	25.0%	12.5%
I have sufficient skills to implement an injury prevention programme	15.8%	34.2%	15.2%	28.3%	6.5%
I have sufficient knowledge to implement an injury prevention programme	13.6%	26.6%	17.4%	32.6%	9.8%

4.4.10 Coaches' Interest in Future Injury Prevention Education and Training

Most coaches (91.3%) indicated that they would be interested in receiving further information and training regarding IPPs, with an additional 4.9% unsure. Coaches indicated that they were likely to participate in or use the majority of methods for future injury prevention education and training mentioned (Table 4.18). Phone applications (58.6%) and instructional DVDs (77.4%) were the methods with the lowest likelihood of use from coaches, where training courses (93.1%), signing up to receive an injury prevention package (90.2%), online resources (90.1%), attending a talk or seminar (86.7%) or the use of instructional posters or information sheets (84.9%) had high likelihoods of coaches' future use.

Table 4.18: Coaches' Level of Interest in Future Injury Prevention Resources

Coaches' Likelihood of Use for Different Injury Prevention Resources			
Resource	Likely	Neutral	Unlikely
Training Courses	93.1%	5.2%	1.7%
Talk or Seminar	86.7%	9.8%	3.5%
Online Resources	90.1%	6.9%	2.9%
Phone Applications	58.6%	17.8%	23.6%
Signing-up to receive an Injury Prevention Package	90.2%	8.1%	1.8%
Instructional DVDs	77.4%	8.1%	14.5%
Instructional Posters and Information Sheets	84.9%	10.5%	4.7%

4.5 Discussion

The aim of this study was to identify coaches' attitude towards, current ability to and willingness to implement injury prevention programmes (IPP) in Ladies Gaelic Football. Coaches are an important factor to consider when investigating acceptance and implementation of IPPs as coaches' knowledge and attitude towards IPP may affect implementation rates (Norcross et al., 2016). IPPs are important in reducing the occurrence and severity of injuries, but current levels of injury prevention implementation in Ladies Gaelic football are unclear.

4.5.1 Current Use, Awareness of and Barriers to Injury Prevention Programmes

An overall lack of awareness of available IPPs may be one of the general explanations for a limited implementation of IPP (Norcross et al., 2016). Compared to 52% of US high school soccer and basketball coaches aware of IPPs (Norcross et al., 2016), 65% of U9-U19 US girls soccer coaches (Morgan et al., 2018) and 74% of South African youth rugby coaches (Sewry et al., 2017), only 21.7% of Ladies Gaelic football coaches were aware of any specific IPPs. The lower levels of awareness in Ladies Gaelic football may be as a result of the voluntary nature of the coaching positions with Ladies Gaelic football, in particular compared coaches who coach as a profession. Just under half (47.8%) of Ladies Gaelic football coaches reported conducting any elements of injury prevention strategies with their team. The most common elements of injury prevention that coaches reported using with their teams were jumping and landing, muscular activation, change of direction, running and dynamic balance, the majority of which are elements in either the GAA 15 or the Activate GAA warm-up. The level of injury prevention implementation among Ladies Gaelic football coaches was greater than that reported in high school soccer and basketball coaches (21%) (Norcross et al., 2016), US girls' soccer club, high school and college level coaches (19.8%) (Joy et al., 2013), male Gaelic football coaches implementing the GAA 15 (7.7%) (Reilly & Kipps, 2017), junior male soccer coaches and backroom staff implementing the FIFA 11 (6%) (O'Brien & Finch, 2016) and U9-U19 US girls club soccer coaches (30%) (Morgan et al., 2018), however, caution must be taken with the comparison as implementation of a specific IPP within Ladies Gaelic football was not measured but elements of injury prevention. The higher implementation observed overall within Ladies Gaelic football coaches may be as a result of the data collected, where coaches were asked if they were implementing an IPP with their team

compared to asking about the implementation of one specific IPP. In addition it is possible that the phrasing and structure of the questions used may have created leading questions and although coaches' were provided with a definition of an IPP, that there is an overall lack of awareness as to what an IPP is within Ladies Gaelic football coaches, which would be further supported by the fact that 78.3% of coaches were unable to identify an IPP and 13.0% of coaches unsure if they were implementing an IPP with their team. A biased higher injury prevention implementation rate among Ladies Gaelic football coaches may be as a result of 35.3% of coaches working or having studied in a medical/ healthcare, sports science, physical education or high-performance role and 92.9% of coaches having completed some form of coaching certification, where they may have had some exposure to the benefits of IPP. Future injury prevention strategies should consider including coach education interventions focusing on the basic understanding and benefits of injury prevention programmes in conjunction with providing education and resource on currently available IPPs specific to Gaelic games.

The motives to participate in IPP by Ladies Gaelic football coaches included; double as a warm-up (75.0%), current research shows benefits of IPP implementation (63.4%) and to improve team performance (46.4%). The motives for US club, high school and college level girls' soccer coaches and Australian junior club community netball coaches were similar, with injury prevention and the reduction of injuries commonly reported in 93% of girls' soccer (Joy et al., 2013) and 79% of junior community netball coaches (Saunders et al., 2010) and improved performance in 36% of girls' soccer (Joy et al., 2013) and 83% of junior community netball coaches (Saunders et al., 2010). Improved performance is a main contributing factor for junior community netball and girls' soccer coaches and similarly for Ladies Gaelic football coaches, where the main goal of all the sports reported is to outscore their opposition and improvements in performance are important factors for success. In order to increase the potential IPP implementation uptake and adherence from coaches, an education programme focusing on the practicality of IPPs doubling as a warm-up and highlighting the current research showing performance and injury prevention benefits should be developed for Ladies Gaelic football coaches as these seem to be important motivating factors for implementation.

The identification of coaches' perception of current barriers to IPP implementation is important for future educational and training strategies, to maximise IPP implementation (Donaldson et al., 2018). Ladies Gaelic football coaches identified a lack of knowledge and information available for coaches as the most common barrier to IPP implementation

(81.5%), along with limited of time during training (42.9%) and no access to equipment (28.3%). The lack of knowledge or training for coaches, was also identified as a common barrier to IPP implementation by 42% of Australian junior club community level netball coaches (Saunders et al., 2010), 64% of US club, high school and college girls' soccer coaches (Joy et al., 2013) but was not considered a primary barrier in US high school soccer and basketball coaches (10%) (Norcross et al., 2016). Knowledge has been identified as an important contributor to intention to complete an activity (Donnell et al., 2018; Register-Mihalik et al., 2013). Thus, by providing Ladies Gaelic football coaches with sufficient knowledge to identify the benefits and importance of IPPs and to implement an IPP, greater coach intention to initiate, implement and adhere to IPPs may occur. Time restrictions was a barrier reported by 42.9% of Ladies Gaelic football coaches, supporting previous findings in 30% of US high school soccer and basketball coaches (Norcross et al., 2016), 43% of US club, high school and college girls' soccer coaches (Joy et al., 2013) and 63% of Australian junior club community level netball coaches (Saunders et al., 2010). The LGFA should consider developing educational programmes and training for coaches to improve their current understanding of IPPs, particularly outlining the practical application of either of the currently available GAA IPPs and their ability to double as a warm-up to assist with the limited time available reported by coaches.

The majority of coaches (91.3%) indicated that they would be interested in receiving further training and education on injury prevention. Participants reported that they would like to participate in training courses (59.8%), online resources (57.2%), talks or seminars (54.9%) and signing up for IPP packages (56.1%), which may assist with the future planning of IPP training and educational plans for coaches. When considering methods for injury prevention education and training programmes for coaches, developing a training course that includes both practical and theoretical aspects is essential, as elite coaches have previously highlighted the importance of including the practical application of theoretical knowledge during coaching education and to allow for the shared knowledge and experiences between coaches (Mesquita et al., 2014). Follow-up online resources with additional and updated IPP exercises or drills and the most recent research should be available for coaches on completion of an injury prevention education or training programme.

4.5.2 Coaches' Attitude towards and Willingness to Implement Injury Prevention Programmes

While IPPs have been developed and shown to reduce the risk of injury and increase neuromuscular outcomes in Gaelic games (Schlingermann et al., 2017; O'Malley et al., 2017), the attitudes of coaches can directly influence the successful implementation and adherence of an IPP (Whatman et al., 2018; Norcross et al., 2016). Most coaches (63.6%) displayed very positive attitudes towards injury prevention, with over two-thirds of coaches disagreeing that IPP take up too much valuable time from necessary tasks during training, and the majority of coaches agreeing that IPPs are relevant and beneficial for their players and will reduce the risk of injury in their team. High school athletes with higher levels of positive attitudes towards concussion were found to have greater levels of concussion reporting events during practice and training and also a reduction in participating in either training or games while symptomatic (Register-Mihalik et al., 2013). It was suggested that athletes with a more positive attitude towards reporting a concussive injury may have a greater level of understanding towards the significance of reporting concussion events and also an increased attitude score may also result in a belief among athletes surrounding their capability to accurately report their injury (Register-Mihalik et al., 2013). Thus, these positive responses towards IPP indicate that coaches may consider implementing an IPP if they were specifically proven to reduce the risk of injury occurrence in Ladies Gaelic footballers, particularly in conjunction with an increased in understanding towards IPPs. Future Ladies Gaelic football injury prevention educational programmes for coaches should focus on current research demonstrating injury prevention benefits for players with the use of IPPs. Additionally, coaches agreed that it is important for both players (92.4%) and coaches (95.1%) to have current knowledge of IPPs, similarly supporting findings in high school coaches (100%) on lower extremity IPPs (Norcross et al., 2016). This highlights the willingness of coaches to partake in educational and training strategies related to injury prevention and IPPs. Future research into the attitudes of players towards injury prevention and IPP may also assist with the current information to develop an effective strategy for the uptake and continued use of IPPs within Ladies Gaelic football.

Willingness investigates openness to an opportunity (Ajzen, 2011) or in this instance coaches' openness to implementing an IPP. While attitude is the most commonly assessed behavioural determinant, coaches' beliefs and willingness to implement an IPP also

influence coaches' decision to implement an IPP (White et al., 2014). Over half of coaches presented with a strong willingness to implement an IPP with 94.6% of coaches agreeing that they are willing to implement an IPP if shown to reduce the chance of injury and 87.5% if proven to improve player performance. Similarly, a greater proportion of adolescent female athletes would be willing to participate in IPPs if proven to reduce the incidence of injury (71%) compared to improving sporting performance (running 51%; jumping 52%) (Martinez et al., 2017). It has been suggested that female athletes were more willing to participate in IPPs if proven to reduce the incidence of injury compared to males who are primarily concerned with improvements in performance (Martinez et al., 2017). Ladies Gaelic football coaches also identified a greater willingness to implement an IPP if shown to reduce the chance of injury occurrence, highlighting the importance of Ladies Gaelic football specific educational interventions focusing on the factors affecting and influencing Ladies Gaelic football coaches. Future research on the benefits of and adherence to either the GAA 15 or Activate GAA Warm-Up in Ladies Gaelic footballers and for prolonged durations are also important prior to the development of coaching education programmes. In addition, 89.7% coaches were also willing and open to changing their current warm-up and training activities for a proven IPP, which was greater than that that observed in high school coaches (50%) (Norcross et al., 2016). This willingness from coaches to change their current warm-up and training activities highlights a current opportunity for IPP coaching education and training and the dissemination of IPP information to coaches. It is important for future research on IPP and IPP educational programmes to focus on the injury prevention benefits of IPP while educating and training Ladies Gaelic football coaches in an attempt to increase the implementation rates and adherence rates of IPPs.

However, high levels of coach intent to implement an IPP may not translate into high levels of implementation and compliance (Frank et al., 2015). Although a high proportion of coaches reported positive attitudes towards and high levels of willingness to implement an IPP, the implementation rate of any elements of injury prevention was low (47.8%) and overall awareness of currently available IPPs was very low (21.7%). Following a workshop, elite female & youth coaches' intention to implement an IPP was increased through increased positive attitudes towards conducting an ACL IPP at the beginning of training session ($z= -2.33$; $p< 0.05$) and substituting an ACL IPP for their current warm-up ($z= -2.69$; $p< 0.05$) (Frank et al., 2015). However, a poor immediate adoption rate of 53% was observed irrelevant of club policies established requiring implementation (Frank

et al., 2015). So, while coaches' attitudes and intention to implement IPPs do not directly translate into uptake and adherence, they may play an important role along with other contributing factors to implementation. In the current study coaches currently implementing elements of injury prevention with their team, had significantly higher and more positive total attitude scores towards injury prevention ($p< 0.001$; $d= 1.06$) and significantly greater willingness to implement an IPP ($p< 0.001$; $d= 1.26$). Strong significant associations with coaches' attitudes ($r= 0.555$; $p< 0.001$) and willingness ($r= 0.645$; $p< 0.001$) levels and their current perceived ability to implement an IPP were also demonstrated. Willingness to complete a task or action has previously been identified as a predictor of behaviour in; pre-adolescents willingness to smoke (Gerrard et al., 2002), individuals with occupational skin disease's willingness to adopt skin protection measures (Matterne et al., 2011) and young adults' willingness and intention to consume amphetamines (Litchfield et al., 2006). When investigating young adults' intention to consume amphetamines, it was concluded as a person's attitude towards a behaviour increases in positivity their willingness to perform the behaviour will increase (Litchfield et al., 2006), which was also observed within the current study with the significantly strong positive associations observed between coaches' attitude towards injury prevention and their willingness to implement an IPP. The development of implementation strategies to alter a coaches' intention to implement an IPP seems to be a multifactorial issue, and not just factored by attitudes or willingness individually. Future injury prevention education and training interventions should consider all potential predictors such as attitude, subjective norm and PBC to examine their impact on improving coaches' intention to implement an IPP and implementation rates.

Coaches who completed an LGFA or GAA coaching certification course also demonstrated significantly greater willingness levels ($p< 0.001$; $d= 1.16$) to implement an IPP compared to coaches who did not. Thus, provision of more Gaelic football specific coaching certification opportunities and upskilling workshops on a regular basis may result in greater levels of coach willingness levels to implement an IPP and in turn increase IPP uptake. An increase in the priority for club and county administrations to ensure coaches have completed an LGFA/GAA coaching certification prior to the commencement of coaching, in addition to the LGFA implementing a monitoring system for assessing coaching certification among coaches through the use of referees may improve uptake. A similar monitoring system has been implemented in South African rugby union, which requires mandatory attendance for coaches in an injury prevention

programme (BokSmart) through biennially attending workshops (Sewry et al., 2017). However, Ladies Gaelic football is an amateur sport and with volunteer coaches and referees, this may be difficult to administer practically. Coaches at county level had significantly higher mean willingness compared to college and school levels (p= 0.019; d= 1.21) and club levels (p= 0.003; d= 0.89). Significantly greater willingness levels were also observed between age categories coached with coaching at adult level demonstrating significantly higher willingness levels compared to underage level (p= 0.018; d= 0.56). These results indicate that improving the willingness levels of coaches with underage teams, club team and school or college teams should be prioritised.

4.5.3 Coaches' Current Perceived Ability to Implement an Injury Prevention Programme

Irrelevant of a coaches' positive perception of their control to implement an IPP, their perceived abilities and capabilities to implement an IPP affects implementation behaviour (White et al., 2014). Despite displaying high willingness and attitude towards implementing IPP, just a small percentage of coaches (13.6%) showed strong levels of perceived ability to implement an IPP. While coaches reported high levels of support from club administration (57.1%), players (75.0%) and parents/ guardians (72.8%) to implement an IPP resource, the availability of educational and training resources was considered a key factor that negatively affected coaches' perceived ability to implement an IPP. Approximately one-third of coaches reported having a lack of access to educational resources, appropriate training equipment and sufficient training facilities to implement an IPP in conjunction with over one-third of coaches reporting not have sufficient experience, skills and knowledge to implement an IPP. Similarly, in high school coaches, only half of the coaches reported having training available to them to implement an IPP (Norcross et al., 2016) and 36% of junior community netball coaches reported a lack of coaching skill, 33% reported a lack of training facilities and 21% reported a lack of training equipment as factors the impeded their implementation of IPPs (Saunders et al., 2010). IPPs that are easy to implement, require minimal equipment and facilities and can be incorporated into a team's training session are suggested to maximise compliance and uptake (Voskanian, 2013). Sufficient coach training on the use of currently available IPP such as the GAA 15 or the Activate GAA Warm-Up, that requires the use of a standard training facility such as a pitch with no additional equipment outside of standard pitch markers that also doubles as a warm-up to maximise the time available to coaches,

may rectify some of the perceived barriers to implementation reported by Ladies Gaelic football coaches.

Greater access to funding, facilities, equipment, and presence of medical and healthcare professionals and coaches, may have an impact on coaches perceived ability to implement an IPP as coaches currently coaching an adult ($p= 0.001$; $d= 0.77$) or county team ($p= 0.014$; $d= 0.83$) displayed significantly greater perceived ability to partake in IPPs. Thus, targeting the collegiate, club and underage team with an IPP that utilise readily available equipment that can be completed sufficiently by coaches is key. Following an ACL IPP workshop in soccer coaches, coaches' perceived behavioural control to implement an ACL IPP increased, where coaches reported feeling more comfortable to teach their team the IPP ($z= -3.07$; $p< 0.05$) and more confident that they could implement an IPP if provided with instruction ($z= -2.24$; $p< 0.05$) (Frank et al., 2015). Thus, workshops may be beneficial for Ladies Gaelic football coaches to increase their perceived ability to implement and IPP. Coaches with one-years coaching experience had significantly lower mean perceived ability than coaches with 6-10 years ($p= 0.032$; $d= 1.12$) and 11-15 years ($p= 0.019$; $d= 1.32$) experience. Providing coaches with the opportunity to communicate with experienced coaches to discuss their current practices and experiences has been identified as a potential method to improve coaches' perceived ability and willingness to implement an IPP within junior community netball (White et al., 2014). A coaching mentoring scheme in Ladies Gaelic football where new coaches are paired with experienced coaches may assist with improving new coaches' perceived ability to implement an IPP, through assisting and observing the implementation of an IPP by more experienced coaches and gaining the practical experience of implementing an IPP. Coaches who completed an LGFA/GAA coaching certification also had significantly higher ability levels ($p= 0.002$; $d= 0.85$) compared to no certifications or other coaching certifications and currently implementing an IPP also demonstrated significant associations with ability levels ($p= 0.000$). Provincial and central Ladies Gaelic football administrations should also consider providing coaches with the opportunity to attend workshops relating to new coaching techniques and research and also injury prevention training and research, to provide them with the knowledge and skills to implement both new coaching techniques and IPPs.

4.5.4 Limitations

As with all research gathering self-completed responses, recall bias and social desirability bias may have occurred. To limit these biases data was gathered anonymously with no contact details or identifying details of coaches gathered or stored. The main limitation of this research is the poor completion rate of only 39.5% of responses being available for analysis. The length of the survey and significant time required to complete the survey in full is likely the cause of the low completion rate. As a result of the poor completion rate, future research using this validated survey may consider using an adapted shorter version with fewer aims and objectives combined or the use of semi-structured interviews on a representative convenience sample of coaches, reducing the duration required and in hopes of increasing the completion rate of responses.

4.6 Conclusion

Coaches' current awareness, attitude towards, willingness to and perceived ability to implement an IPP all impact a coaches' decision to introduce and implement an IPP with their team. A small percentage of coaches are currently aware of specific IPPs available for Gaelic games or any IPP generally. Less than half of coaches are currently conducting any elements of injury prevention with their current teams, where jumping and landing, muscular activation and change of direction exercises were most commonly included. Coaches' lack of awareness towards current IPPs available, has been shown to impact implementation which may be the case in the current study. Lack of knowledge or information for coaches was the most commonly reported barrier for implementing an IPP by Ladies Gaelic football coaches followed by restricted time during training sessions and a limited access to equipment. Although a large proportion of coaches presented with strongly positive attitudes towards IPP and strong levels of willingness to implement an IPP, just a small proportion of coaches showed a strong perceived ability to currently implement an IPP. In particular, underage and club levels coaches demonstrated low levels of perceived ability. An inclusive injury prevention educational and training programme for all coaches with an added focused on coaches working with underage teams may assist in IPP implementation rates and long-term adherence. IPP training for coaches, in particular for underage and club level coaches, should focus on the reduction of injury occurrence benefits for players and also the practicality of current IPP that require no additional facilities or equipment and can double as a warm-up to reduce the pressure of time restrictions during training sessions.

Chapter 5

Thesis Conclusion & Future Recommendations

5.1 Conclusion

After a review of the currently available literature, a lack of injury epidemiological research specific to Ladies Gaelic football was identified and in particular adolescent Ladies Gaelic footballers. Furthermore, although injury prevention programmes (IPP) specific to Gaelic games are available, the current implementation rates and Ladies Gaelic football coaches' attitude towards these IPPs was unclear. An injury incidence of 10.32 injuries per 1,000 hours Ladies Gaelic football exposure was found, with a higher injury incidence of 23.24 injuries per 1,000 hours was observed in U-16 players compared to 7.53 injuries per 1,000 hours in U-14 players. Match injury incidence was also greater than that observed during training (17.6 versus 5.83 injuries per 1,000 hours), where overall calf and knee injuries were prominent. Although there is a vast amount of IPPs available, including Gaelic games specific IPPs, less than a quarter of Ladies Gaelic football coaches were aware of any specific IPPs. Although there was a poor level of awareness, 47.8% of coaches reported conducting elements of injury prevention with their current teams. A strong attitude and willingness towards IPP was observed, however less than one-eighth of coaches perceived that they had a strong ability to currently implement an IPP, particularly in underage and club level coaches. Injury prevention education and training strategies, focusing on the motives and barriers specifically identified by Ladies Gaelic football coaches, should be developed to improve coaches' perceived ability to implement an IPP, aiming to improve uptake, implementation and adherence to IPPs. Injury prevention strategies specialised for adolescent Ladies Gaelic footballers that is specific to the injuries observed, and considers the current barriers to implement identified by coaches should be also considered to have an IPP with a successful uptake, implementation and adherence.

5.2 Future Recommendations

This study presents the initial research describing the epidemiology of injury in club level adolescent Ladies Gaelic football and the basis for understanding Ladies Gaelic football coaches' attitudes, willingness, knowledge and perceived abilities to implement an IPP. Thus, there is a clear need for future research which is specified below.

Injury Epidemiology

- A longer injury surveillance duration to include both the pre-season and the entire season and multiple seasons should be considered to truly represent the injury occurrence, severe injuries and impact injuries have on adolescent Ladies Gaelic footballers.
- Future epidemiological research on both younger (U-12) and older (U-16 & U-18) adolescent Ladies Gaelic footballers should be implemented to examine where the injury incidence, characteristics and burden are similar to the age group examined in this thesis.
- Future research should develop an injury prevention programme designed to target the specific injuries sustained by adolescent Ladies Gaelic footballers that include elements of upper extremity injury prevention to prevent hand and finger injuries. The effectiveness of the IPP in the reducing injury occurrence and severity in conjunction with feedback from coaches regarding the practicality and any implementation issues or suggestions should also be conducted.
- Future research into the aetiology of injuries, specifically the hand and finger injuries sustained by adolescent Ladies Gaelic footballers due to contact with the ball should be investigated. In conjunction with the further investigation of aetiology, examining how changes to ball size or weight for adolescent Ladies Gaelic footballers or the development of protective equipment for the hands and fingers may reduce injury incidence should be considered.
- Physical levels of fatigue and stress were only measured in the training loads in the current study so further research to include physical and emotional fatigue and stress may give a greater understanding of the global effects of fatigue and stress on injury
- Prolonged training load analysis in conjunction with longer injury surveillance duration will allow for the investigation of periods of training load intensification

such as the preseason or periods of increased competition, and their effect on injury incidence.

Coaches Attitude towards Injury Prevention

- Future research should focus on the development of an IPP implementation and educational strategy that aims to address the barriers identified and encourage the implementation and acceptance of IPP by Ladies Gaelic football coaches at all levels and age categories. On the completion of the implementation and education strategy the initial implementation rates and the long-term adherence to IPP implementation should be investigated.
- IPPs are currently available for Gaelic games, additional research may look at the different methods of dissemination of injury prevention strategies that were identified by coaches in the current study and examine their effects on improving IPP implementation and adherence.
- Future research into the practicality or barriers regarding the real-world implementation of the currently available GAA 15 and Activate GAA Warm-Up by Ladies Gaelic football coaches' may also be conducted as a basis for future IPP training and educational programmes and the development of new IPPs or adaption of current IPPs.
- Future research into the development of educational resources, training and guidelines particularly for coaches working with underage teams should be considered to provide a fully inclusive IPP for all Ladies Gaelic football players, teams and coaches, as coaches with underage teams reported lower levels of perceived ability to implement an IPP.

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Appendices

Appendix A: Volunteer Information Sheet

Connect & Discover

Volunteer Information Sheet

Principal Investigator: Ms Emma Kavanagh

Supervisors: Dr Siobhán O'Connor
Dr Niamh Ní Chéilleachair

Purpose of Study

The aim of the study is to establish musculoskeletal injury incidence in Gaelic football for female adolescents, identify how common injuries are in female adolescents and how they affect participation and absence from physical activity, sport and school. We are also looking at levels of physical activity and training and will measure the levels using a hand-written weekly training log which will be filled out once a week.

What is required of you?

You are required to report to me any injury sustained during the week, whether or not your symptoms have resolved by the examination day. Once you report to me I will complete a free of charge musculoskeletal examination of your injury and inform you of the injury diagnosis. You will also be required to complete a weekly written training diary log that will record the time you spend partaking in physical activity and sport each week.

Location and Supervision

All injury examinations will be completed within the club. I, the principal investigator, am a certified Sports Rehabilitator, with full graduate membership of BASRaT including professional indemnity insurance, and will be assisted by final year BSc (Hons) in Athletic and Rehabilitation Therapy students from Athlone I.T. The final year students have been Garda Vetted and have previous experience working with the public from placements and two years of clinical placements prior to assisting on this research study. They will assist with the injury examinations and completing injury report forms. I, the principal investigator, have also been Garda vetted and completed the Child Protection in Sport Awareness Workshop and the Safeguarding 1: Child Welfare & Protection Basic Awareness Workshop, as well as previous experience working with adolescents from a Sports Rehabilitation perspective and from a sports coaching and refereeing perspective.

Testing Procedures

Baseline Testing and Pre-participation questionnaire- You will be required to complete some baseline testing, which will include height, weight and leg-length measurements as well as completing a 3-hop tests. The test requires you to perform 3 continuous single leg hops and control the landing. The distance hopped along with jump heights and ground contact times will be measured, you will complete three measured trials for each leg.

Musculoskeletal Injury Examination- Injury examinations will be conducted using standard assessment techniques. A standard injury report form will be completed using your assigned ID number instead of your name to ensure your details remain confidential. Once a diagnosis has been made you will be informed of the diagnosis and will be provided with the referral details of an appropriate healthcare professional (eg. GP, chartered physiotherapist, sports rehabilitator, athletic rehabilitation therapist) if deemed necessary.

Psychological Questionnaires-After your injury has been assessed by the principal investigator or the final year students, you will be required to complete the Athlete Fear Avoidance Questionnaire (AFAQ). Instructions on how to complete the questionnaire will be explained by the principal investigator and you will be given every opportunity to ask any questions which may arise. A 15-minute period will then be allocated to allow you to complete the questionnaire. You are free to complete the questionnaire anywhere in the assessment room in order to ensure those present do not influence your answers but it must be completed before you leave the room. Prior to your return to play, you will be required to return to the assessment room in order to complete the Injury-Psychological Readiness to Return to Sport (I-PRSS) Scale.

Training Diary Logs and Daily Check-Ins- You will fill out a training diary which will record the amount of training and physical activity you participate in each week. The written training diary will be completed that week, once a week during your training session using a standardised hand-written training log.

Potential Risks

Physical discomfort may occur during the musculoskeletal injury examination, as with any musculoskeletal examination some degree of discomfort or pain will be reproduced in order to make an accurate injury diagnosis. Any physical discomfort that may occur is no greater than that associated with a musculoskeletal examination from any physician, athletic rehabilitation therapist/ sports rehabilitator or chartered physiotherapist.

Benefits

By taking part in this study you will receive free of charge a musculoskeletal injury examination and once you have been given your diagnosis you will also be given a list of appropriate referrals to treat your injury. The referral list given may be to local physician, athletic rehabilitation therapist/ sports rehabilitator or chartered physiotherapist. This study hopes to identify injury trends in order to design and implement injury prevention programmes to reduce future injury to females.

Confidentiality

The results and data collected from this study are regarded as confidential and will be used by the investigating team only. All injury report forms and training diary logs will be stored in a locked filing cabinet and will not leave Athlone IT. This cabinet will only be accessible to the principal investigator and the supervisors of this study. Your data will be kept anonymous through a personal ID number and the data will be destroyed 5 years after publication of this study.

Freedom of Withdrawal

Participation in this study is completely voluntary and therefore you have the right to withdraw from the study at any time, without prior notice or reason.

We hope that you are willing to participate in this research study, if you have any further questions or concerns please feel free to get in contact.

Emma Kavanagh- Principal Investigator
Email: e.kavanagh@research.ait.ie

Supervisors:
Dr Siobhán O'Connor- siobhan.oconnor@dcu.ie
Dr Niamh Ní Chéilleachair- nnicheilleachair@ait.ie

Appendix B: Informed Consent Forms

Informed Consent Form

Epidemiology of Physical Activity Related Musculoskeletal Injury in Female Secondary School Adolescents in One Year

- I have read and understand all the information presented in the volunteer information sheet provided.
- I understand what the project entails and what the results will be used for.
- I comprehend all testing procedures and they have been verbally explained to me in full.
- I am aware of the potential risks and benefits involved with participating in the study.
- I understand that any information about my daughter will be kept confidential and will be coded using subject IDs.
- I recognise that the results of the study may be published but the identity of my daughter will remain confidential.
- I am aware that participation in this study is voluntary and that my daughter can withdraw/I can withdraw my daughter from the study at any time without giving a reason.
- I understand that if I/my daughter has any questions regarding any aspect of this research study I/my daughter can contact any of the investigators involved with this study.

Participant's (Adolescents) Name: _____

Parent/ Guardian's Signature: _____

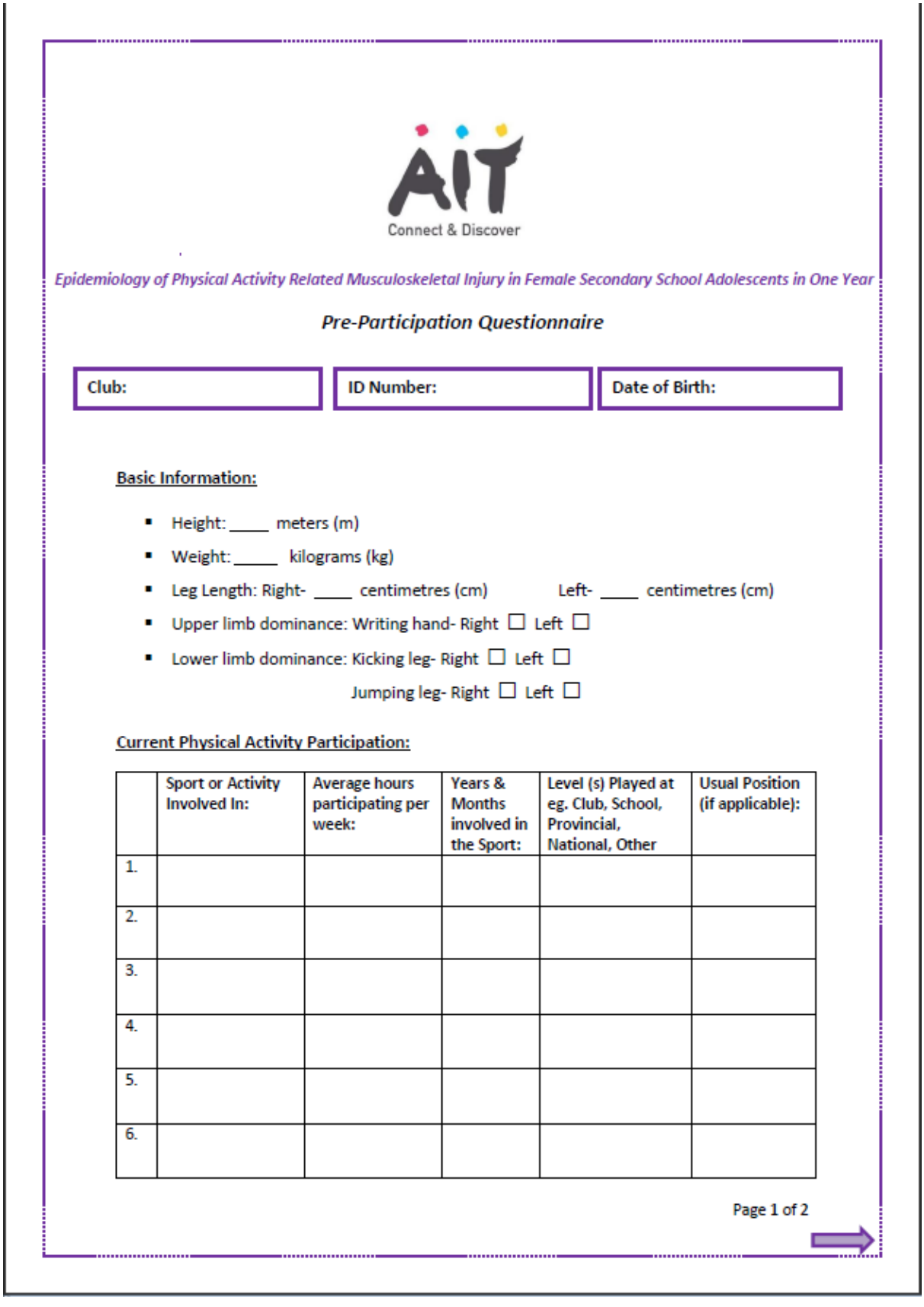
Participant's (Adolescents) Signature: _____

Date: _____

Principal Investigator's Signature: _____

Date: _____

Appendix C: Pre-Participation Questionnaire



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Epidemiology of Physical Activity Related Musculoskeletal Injury in Female Secondary School Adolescents in One Year

Pre-Participation Questionnaire

Club:	ID Number:	Date of Birth:

Basic Information:

- Height: ____ meters (m)
- Weight: _____ kilograms (kg)
- Leg Length: Right- ____ centimetres (cm) Left- ____ centimetres (cm)
- Upper limb dominance: Writing hand- Right ☐ Left ☐
- Lower limb dominance: Kicking leg- Right ☐ Left ☐
  Jumping leg- Right ☐ Left ☐

Current Physical Activity Participation:

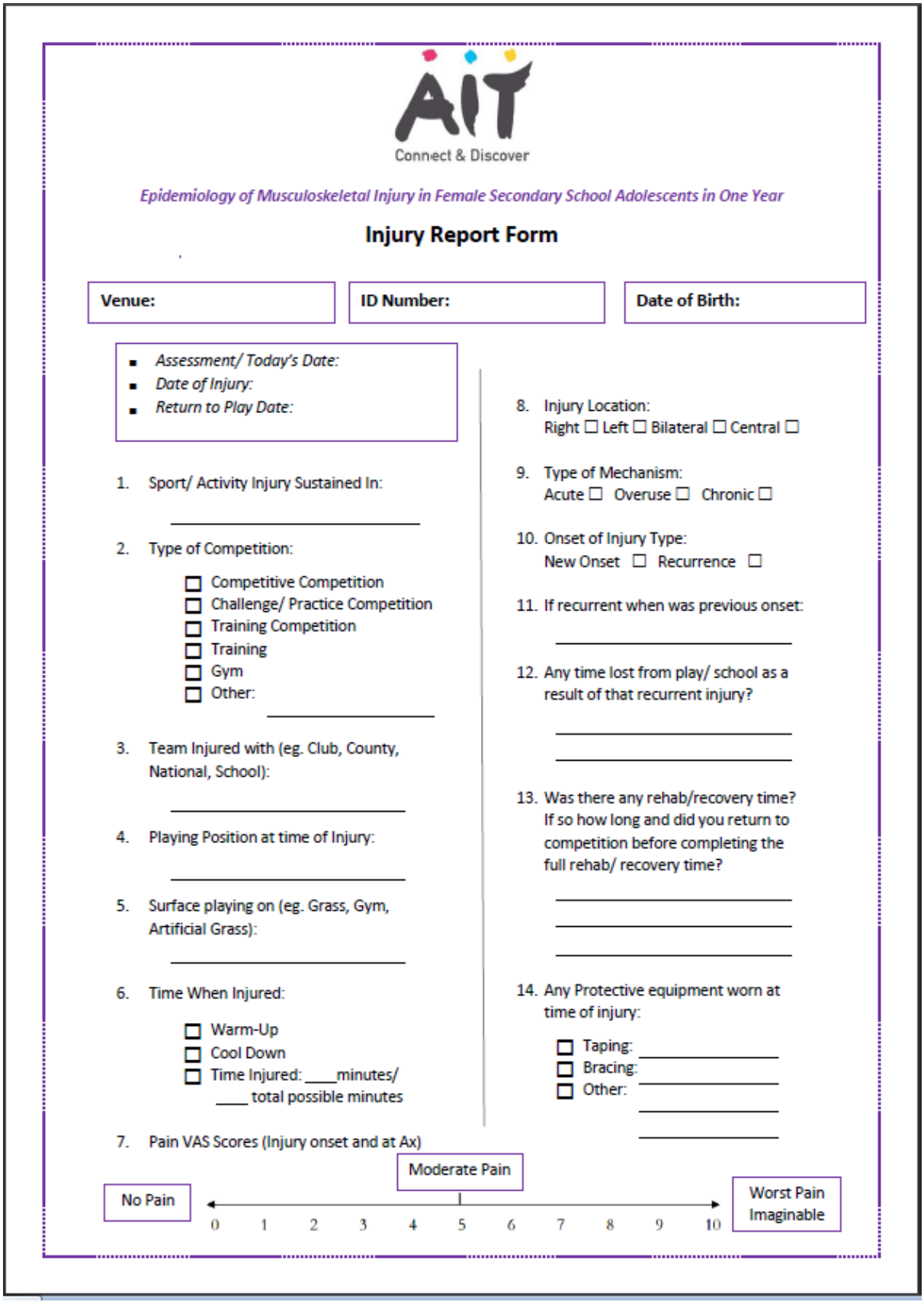
	Sport or Activity Involved In:	Average hours participating per week:	Years & Months involved in the Sport:	Level (s) Played at eg. Club, School, Provincial, National, Other	Usual Position (if applicable):
1.					
2.					
3.					
4.					
5.					
6.					

Page 1 of 2

Injury History

1. Over the past 12 months have you sustained a musculoskeletal injury while participating in some form of physical activity? Yes ☐ No ☐
2. Have you had more than one injury over the last 12 months? Yes ☐ No ☐
   If yes how many different injuries have you had? _____
3. Please state the most severe injury you had eg. Ankle sprain, hamstring strain? _____
4. Has the same injury ever re-occurred? Yes ☐ No ☐
   If yes when did it occur and for how long? _____
5. Did you receive treatment for your injury? Yes ☐ No ☐
6. What form of treatment did you receive? Hospital/ A&E ☐ GP ☐ Chartered Physio ☐
   Athletic Rehabilitation Therapist/ Sports Rehabilitator ☐ Other ☐ _____
7. Did your injury require a scan? Yes ☐ No ☐, if so what type of scan? _____
8. Did your injury require surgery? Yes ☐ No ☐, if so what? _____
9. As a result of your injury did you lose time from your sport/ activity? Yes ☐ No ☐
   If yes how long? _____
10. As a result of your injury did you lose time from school? Yes ☐ No ☐
    If yes how long (if only 1 day for scan etc. include that)? _____
11. Did you complete any rehabilitation for your injury? Yes ☐ No ☐
12. Do you feel you completed adequate rehabilitation before returning to physical activity?
    Yes ☐ No ☐
13. If you felt like you **did not** complete adequate rehab/ recovery before returning to physical activity, why? _____
    _____
14. Do you feel that you returned to activity too early? Yes ☐ No ☐
15. Do you feel like there was pressure on you to return to activity early? Yes ☐ No ☐
16. If so, who do you feel put pressure on you? Self ☐ Coach ☐ Parent(s) ☐ Other ☐
17. Do you feel that your performance is similar or improved to that pre-injury? Yes ☐ No ☐
    If no please explain why _____
    _____

Appendix D: Injury Report Forms



Connect & Discover

Epidemiology of Musculoskeletal Injury in Female Secondary School Adolescents in One Year

Injury Report Form

Venue:	ID Number:	Date of Birth:

- *Assessment/ Today's Date:*
- *Date of Injury:*
- *Return to Play Date:*

1. Sport/ Activity Injury Sustained In:

   _____

2. Type of Competition:

   - ☐ Competitive Competition
   - ☐ Challenge/ Practice Competition
   - ☐ Training Competition
   - ☐ Training
   - ☐ Gym
   - ☐ Other: _____

3. Team Injured with (eg. Club, County, National, School):

   _____

4. Playing Position at time of Injury:

   _____

5. Surface playing on (eg. Grass, Gym, Artificial Grass):

   _____

6. Time When Injured:

   - ☐ Warm-Up
   - ☐ Cool Down
   - ☐ Time Injured: ____minutes/ ____ total possible minutes

7. Pain VAS Scores (Injury onset and at Ax)

   No Pain — Moderate Pain — Worst Pain Imaginable

   0 1 2 3 4 5 6 7 8 9 10

8. Injury Location:
   Right ☐ Left ☐ Bilateral ☐ Central ☐

9. Type of Mechanism:
   Acute ☐ Overuse ☐ Chronic ☐

10. Onset of Injury Type:
    New Onset ☐ Recurrence ☐

11. If recurrent when was previous onset:

    _____

12. Any time lost from play/ school as a result of that recurrent injury?

    _____

    _____

13. Was there any rehab/recovery time? If so how long and did you return to competition before completing the full rehab/ recovery time?

    _____

    _____

    _____

14. Any Protective equipment worn at time of injury:

    - ☐ Taping: _____
    - ☐ Bracing: _____
    - ☐ Other: _____

      _____

      _____

15. Injured Body Part:

- ☐ Head
- ☐ Face
- ☐ Eyes
- ☐ Ear
- ☐ Nose
- ☐ Teeth
- ☐ Neck/ C-Spine
- ☐ Sternum
- ☐ Ribs
- ☐ Upper Back/ T-Spine
- ☐ Abdomen
- ☐ Lower Back/ L-Spine
- ☐ Pelvis/ Sacrum/ SI
- ☐ Hip
- ☐ Groin
- ☐ Thigh
- ☐ Knee
- ☐ Calf/ Achilles
- ☐ Shin
- ☐ Ankle
- ☐ Foot
- ☐ Toes
- ☐ Clavicle
- ☐ Upper Arm
- ☐ Elbow
- ☐ Forearm
- ☐ Wrist
- ☐ Hand
- ☐ Fingers
- ☐ Thumb

16. Mechanism of Injury:

- ☐ Walking
- ☐ Running
- ☐ Sprinting
- ☐ Twisting
- ☐ Turning
- ☐ Backtracking
- ☐ Pivoting
- ☐ Jumping
- ☐ Landing
- ☐ Kicking
- ☐ Throwing
- ☐ Striking
- ☐ Shooting
- ☐ Passing
- ☐ Tackling
- ☐ Being Tackled
- ☐ Foul Play
- ☐ Equipment Failure
- ☐ Contact with Other Athlete
- ☐ Contact with Moving Object
- ☐ Contact with Stationary Object
- ☐ Overuse
- ☐ No MOI Recalled
- ☐ Sports Specific: _____
- ☐ Other: _____

17. Type of Injury

Muscle:

- ☐ Muscle Strain/Tear
- ☐ Muscle Cramp/ DOMS
- ☐ Muscle Tightness
- ☐ Muscle Contusion/ Haematoma

Ligament:

- ☐ Ligament Sprain
- ☐ Ligament Avulsion/ Rupture

Tendon:

- ☐ Acute Tendon Injury
- ☐ Tendinopathy
- ☐ Tendon Avulsion/ Rupture

Joint

- ☐ General Joint Injury
- ☐ Global Joint Instability
- ☐ Meniscal/ Cartilage damage
- ☐ Dislocation
- ☐ Subluxation
- ☐ Spinal Facet Joint
- ☐ Bursitis

Bone

- ☐ Bone Bruising
- ☐ Fracture
- ☐ Stress Fracture
- ☐ Other: _____

Other

- ☐ Concussion + loss of consciousness
- ☐ Concussion - loss of consciousness
- ☐ Abrasion
- ☐ Laceration
- ☐ Nerve Injury
- ☐ Dental Injury
- ☐ Spinal Disc
- ☐ Other: _____

18. Injury Diagnosis (incl. grade & structure):

19. Referral Advised: Yes ☐ No ☐

20. Referral Type Advised:

- ☐ GP
- ☐ Hospital
- ☐ Physio/ARTC/ GSR
- ☐ Scan _____

21. Any Other Information:

Epidemiology of Physical Activity Related Musculoskeletal Injury in Female Secondary School Adolescents in One Year

Weekly Training Log

ID Number: ***Today's Date:*** ***Week Number:***

- What to Include: Any individual or team training including any gym or condition sessions as well as regular sports specific training. Position: If more than one position played during game use position where majority of time was spent. No position required if training session.
- Team Played with: Just state club/county/ school/ national for which organisation the physical activity was completed, if physical activity is a class, walk, cycle or class use Self if not completed as part of a session for an organisation.
- Duration/ Time Player: duration of training or duration of match played in mins (eg. If taken off at half time state 30mins played).
- Session RPE: rating the difficulty of the session using the following scale;

0	1	2	3	4	5	6	7	8	9	10
Rest	Very Very Easy	Easy	Moderate	Somewhat Hard	Hard		Very Hard			Maximal

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Sport & Position:							
Training/Match/ Competition:							
Team Played with:							
Duration/ Time Played:	mins	mins	mins	mins	mins	mins	mins
Session RPE:	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10
Injury Occurred?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Sport & Position:							
Training/Match/ Competition:							
Team Played with:							
Duration/ Time Played:	mins	mins	mins	mins	mins	mins	mins
Session RPE:	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10
Injury Occurred?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Sport & Position:							
Training/Match/ Competition:							
Team Played with:							
Duration/ Time Played:	mins	mins	mins	mins	mins	mins	mins
Session RPE:	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10
Injury Occurred?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Sport & Position:							
Training/Match/ Competition:							
Team Played with:							
Duration/ Time Played:	mins	mins	mins	mins	mins	mins	mins
Session RPE:	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10	/ 10
Injury Occurred?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

Appendix F: Final Online Survey Post Delphi Validation

Delphi Review- Round 3/Draft 3		
	Question	**Answers**
Participant Demographic		
1.	What is your gender?	• Female • Male • Other _____ • Prefer not to say
2.	What was your age at your last birthday? (whole numbers)	
3.	Have you previous experience playing Gaelic Games for at least one season with a club? (tick all that apply)	• Yes, Ladies Gaelic Football • Yes, Gaelic Football • Yes, Camogie • Yes, Hurling • Yes, Handball • No
4.	What is the highest level you have played at? (tick one answer)	• Interprovincial • Adult County • College/ University • Adult Club • Underage County • Underage Club • Secondary School • Primary School • Other _____
Coaching Background		
5.	In total how many years have you coached in Ladies Gaelic Football? (whole numbers)	
6.	I coach in Ladies Gaelic football because…. (tick all that apply)	• I want to stay involved in Gaelic Games • I have a daughter playing Ladies Gaelic football • I want to give back to my club/ the sport • I enjoy the challenge of coaching • I enjoy the excitement of competition

		• I wanted to contribute to the development of players and skills in Ladies Gaelic Football • No one else wanted to do it • I was asked by the club to do it • Other _____
7.	What age category have you **previously** coached? (tick all that apply)	• U-6 • U-8 • U-10 • U-12 • U-14 • U-16 • U-18/ Minor • Adult- Junior • Adult- Intermediate • Adult- Senior • Other _____
8.	What age category do you **currently** coach? (tick all that apply)	• U-6 • U-8 • U-10 • U-12 • U-14 • U-16 • U-18/ Minor • Adult- Junior • Adult- Intermediate • Adult- Senior • Other _____
9.	What is the **highest** level you have coached at? (tick one answer)	• Interprovincial • Adult County • College/University • Adult Club • Underage County • Underage Club • Secondary School • Primary School • Other _____

10.	What level do you **currently** coach? (tick all that apply)	• Interprovincial • Adult County • College/University • Adult Club • Underage County • Underage Club • Secondary School • Primary School • Other _____
11.	How long have you been coaching these **current** teams? (Complete all that apply in years)	• Interprovincial, _____ • Adult County, _____ • College/University, _____ • Adult Club, _____ • Underage County, _____ • Underage Club, _____ • Secondary School, _____ • Primary School, _____ • Other, _____
12.	What is the highest level of education you have completed? (select one answer)	• Primary School • Junior Certificate • Leaving Certificate • College/ University- Certificate • College/ University- Diploma • College/ University- Degree • Postgraduate • Other _____
13.	Have you ever studied towards or worked in any of the following areas: medical or healthcare provision, sports science, physical education or high-performance sport?	• Yes • No
14.	If **yes**, what have you studied or what are you studying towards?	

	15.	If **yes**, how long have you held that role?	• _____ years • Still Studying • Not Applicable
	16.	Have you completed any coaching qualifications? (tick all that apply)	• LGFA FUNdamental's Course • LGFA Level 1 • GAA Foundation Award • GAA Award 1 Coach Education • GAA Award 2 Coach Education • FAI Kick Start 1 • FAI Kick Start 2 • IRFU- Mini Rugby • IRFU- Foundation Level • IRFU- Level 1 • IRFU- Level 2 • IRFU- Level 3 • No • Other _____
	17.	Have you completed any first aid/ responder training? (tick all that apply)	• First Aid Responder (FAR) • Cardiac First Responder (CFR) • Occupational First Aid • Emergency First Responder (EFR) • Emergency Medical Technician (EMT) • Paramedic • Advanced Paramedic • Qualified Nurse • Qualified Doctor • No • Other _____
Injuries		**The following questions consider your role coaching your MAIN team (which is the team you spend the most time coaching i.e. more than 50% coaching time)**	

	18.	Approximately how many players on your main team sustained an injury last season, which resulted in them being unable to participate in training or games for a minimum of 24 hours?	• None • 1-5 players • 6-10 players • 11-15 players • 16-20 players • 21-25 players • 25+ players • Not applicable • Exact Number _____
	19.	Does your current main team have access to medical/ healthcare professionals (degree certified) for all training sessions and matches? (tick all that apply)	• Yes • No • Training Sessions Only • Matches Only • Some Matches • Some Training Sessions • Other _____
	20.	If your team does not have a medical/ healthcare professional present, who would deal with any injuries?	• Yourself (Coach) • Assistant Coach/ Selector • A Player • Another Club Member • Spectator • Volunteer • No One • Other _____
	21.	Do you ever have to perform any aspect of first aid while coaching?	• Yes, Rarely (once a year) • Yes, Sometimes (monthly) • Yes, Often (weekly) • No • Other _____
Injury Prevention	Injury Prevetion Programmes- specifically designed programmes developed to try prevent or reduce the severity of injuries while playing in sports such as Gaelic football, before they occur		
	22.	Are you currently aware of any specific injury prevention programmes for Gaelic games or injury prevention programmes in general?	• No • If YES, what injury prevention programmes_____ __

23.	Are you currently conducting injury prevention programmes with your team? *If "No" is selected the participant will be redirected to Question 31*	• Yes • No • Unsure • Other _____
24.	If you are currently conducting an injury prevention programme, what encouraged you to do so? (select all that apply)	• Advised to by medical and healthcare professionals • It doubles as a warm-up • Current research shows benefits • Players requested it • To improve team performance • Due to high levels of injuries seen in previous seasons • Other teams/ coaches in the club have found it beneficial • I observed elite/ high performance teams participating in injury prevention programmes • Other _____
25.	In your team who is responsible for delivering the injury prevention programme? (tick one answer)	• Coach • Assistant Coach/ Selector • Medical and Healthcare Professionals • Player/ Captain • Sports/ Exercise Scientist • Strength & Conditioning Coach • Any of the above • All of the above • Other _____

26.	What elements are included in your injury prevention programme? (tick all that apply)	• Running • Muscular Activation (e.g. Glutes) • Neuromuscular Strengthening • Change of Direction • Jumping and Landing • Dynamic Balance • Other _____
27.	How often is your team participating in injury prevention programmes?	• Once off/ pre-season screening and testing • During every training session and match • During every training session • During every match • During one training session a week • Player self-administration outside of training/ matches • Other _____
28.	How much time is allocated for the injury prevention programme per **training session**?	• None • 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 20+ minutes
29.	How much time is allocated for the injury prevention programme per **match**?	• None • 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 20+ minutes

30.	Where did you source your injury prevention programme? (tick all that apply)	• From current research • Self-designed • Provided by a Medical and Healthcare Professional • Provided by a Strength & Conditioning coach • Saw it online/ on social media, if so where online _____ • Other _____
31.	What are the current barriers to implementing an injury prevention programme in Ladies Gaelic football? (tick all that you feel applies)	• Lack of time during training sessions • Cost • Lack of knowledge/ information for coaches • Lack of interest from players • No access to equipment • Other _____
32.	Please respond to the following questions surrounding injury prevention programmes. Please select one answer that best fits your opinion a) Injuries are an issue with my team b) It is important for coaches to have current knowledge of injury prevention programmes c) It is important for players to have current knowledge of injury prevention programmes d) Injury prevention is important during training sessions e) Injury prevention programmes cost too much money f) The activities included in injury prevention programmes are relevant and beneficial to my players g) I believe that using an injury prevention programme will reduce the number of injuries in my team h) Injury preventions programmes take up too much precious training time away from necessary tasks	• Strongly Disagree • Disagree • Neither disagree or agree, • Agree • Strongly Agree • Not Applicable

	33.	The statements below are related to your **understanding** of the current implementations and participation in injury prevention programmes. Please select one answer that best fits your opinion. a) Most Ladies Gaelic football coaches are using injury prevention programmes with their teams b) Injury prevention programmes are only for top level senior club or intercountry teams c) Only adult teams are participating in injury prevention programmes d) Injury prevention programmes should not be used with Underage teams e) Players are requesting to participate in injury prevention programmes f) Only teams with access to sports/ exercise scientists are participating in injury prevention programmes g) Only teams with access to medical/ healthcare professionals are participating in injury prevention programmes	• Strongly Disagree • Disagree • Neither disagree or agree, • Agree • Strongly Agree • Not Applicable
	34.	The statements below are related to your **willingness to participate** in injury prevention programmes. Please select one answer that best fits your opinion. a) I would be willing to include an injury prevention programme if it is shown to significantly lower the chance of injury occurrence b) I would implement an injury prevention programme if it was proven to improve player performance c) My team's training sessions are not long enough to devote time to injury prevention d) I am not willing to participate as I haven't received training in order to implement an injury prevention programme e) It is the responsibility of medical/ healthcare professionals or other exercise professionals to implement the injury prevention programme f) I am not willing to change the current warm-up and training activities that I am currently using g) My players would not be willing to complete the injury prevention programmes h) I do not have access to anyone with the appropriate skills or knowledge to assist me with implementing an injury prevention programme	• Strongly Disagree • Disagree • Neither disagree or agree, • Agree • Strongly Agree • Not Applicable

	35.	The following questions are related to your **current ability** to conduct an injury prevention program with your current team(s). Please select one answer that best fits your opinion. a) I have sufficient knowledge to implement an injury prevention programme b) I have sufficient skills to implement an injury prevention programme c) I do not have sufficient experience conducting injury prevention programmes d) I have adequate knowledge to explain the benefits and reasons for participating in injury prevention e) I have sufficient use of facilities to implement an injury prevention programme f) I do not have access to appropriate training equipment to implement an injury prevention programme g) I have sufficient educational resources available to me to assist with implementing an injury prevention programme h) I have no problems getting my players to participate in injury prevention programmes i) I have no issues or concerns from players about participating in injury prevention programmes j) I have no issues or concerns from players' parents/ guardians about participation in injury prevention programmes k) I feel poor player attendance at training will offset the benefits of conducting an injury prevention programme l) I have the support of the club/ county administration to implement an injury prevention programme	• Strongly Disagree • Disagree • Neither disagree or agree, • Agree • Strongly Agree • Not Applicable
	36.	What would reduce any of the previously identified barriers to the implementation of injury prevention programmes in Ladies Gaelic football?	
	37.	Would you be interested in receiving further education and knowledge on injury prevention programmes?	• Yes • No • Unsure • Other _____

38.	The statements below are related to your opinions and preference of types of future injury prevention education and training. Please select one answer that best fits your opinion. On a scale from very likely to very unlikely, how likely would you be to participate in/use; a) Injury Prevention training courses b) Attend an injury prevention talk/ seminar c) Online injury prevention resources d) Phone application for injury prevention programmes e) Sign-up to receive an injury prevention package f) Instructional DVD's g) Instructional posters and information sheets	• Very Likely • Likely • Neither Likely or Unlikely • Unlikely • Very Unlikely • Not Applicable
Warm-Up		
39.	Does your team currently participate in a **warm-up** prior to every match and training session, that **differs** to your injury prevention programme? *If "No, and I don't use an Injury Prevention Programme" is selected the participant will be redirected to Question 44* *If "No" is selected the participant will be redirected to Question 45*	• Yes, All Matches and Training Sessions • Yes, Matches Only • Yes, Training Sessions Only • No, and I don't use an Injury Prevention Programme • No • Other _____
40.	Who is responsible for conducting the warm-up?	• Coach • Assistant Coach/ Selector • Sports/ Exercise Scientist • Medical/ Healthcare Professional • Player/ Captain • Other _____

41.	What elements are included in your team's **current** warm-up? (tick all that apply)	• Jogging • Static Stretching • Dynamic Stretching • Ball Skills • Foam Rolling • Resistance Bands • Small Sided Games • Other _____
42.	How long do you allow for a warm-up prior to a training session?	• 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 21-25 minutes • 25+
43.	How long do you allow for a warm-up prior to a match?	• 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 21-25 minutes • 25+
44.	If your team does not participate in a warm-up please provide any reasons for this choice. (tick all that apply)	• I do not believe they will help reduce the risk of injury • I do not believe they will help performance • Not enough time before training sessions/ matches • I do not have the knowledge to do it/them • My team is not willing to participate • Other _____
Cool-Down		

45.	Does your team currently participate in a **cool-down** after every match and training session? *If "No" is selected the participant will be redirected to Question 50*	• Yes, All Matches and Training Sessions • Yes, Matches Only • Yes, Training Sessions Only • No • Other _____
46.	Who is responsible for conducting the cool-down?	• Coach • Assistant Coach/ Selector • Sports/ Exercise Scientist • Medical/ Healthcare Professional • Player/ Captain • Other _____
47.	What elements are included in your team's current **cool-down?** (tick all that apply)	• Jogging • Static Stretching • Partnered Stretching • Ice baths • Foam Rolling • Other _____
48.	How long do you allow for a cool-down after a training session?	• 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 21-25 minutes • 25+ • Not Applicable
49.	How long do you allow for a cool-down after a match?	• 1-5 minutes • 6-10 minutes • 11-15 minutes • 16-20 minutes • 21-25 minutes • 25+ • Not Applicable

50.	If your team does not participate in a cool-down, please provide any reasons for this choice. (tick all that apply)	• I do not believe they will help reduce the risk of injury • I do not believe they will help performance • Not enough time after training sessions/ matches • I do not have the knowledge to do it/them • My team is not willing to participate • Other _____
Additional Comments		
51.	Do you have any other comment in relation to the usefulness of injury prevention in Ladies Gaelic football?	• Yes, _____ • No
52.	Do you have any other comment in relation to the beliefs of injury prevention in Ladies Gaelic football?	• Yes, _____ • No
53.	Do you have any other comments in relation to the barriers to implementing injury prevention programmes in Ladies Gaelic football?	• Yes, _____ • No
54.	Do you have any other comments in relation to injury prevention educational programmes in Ladies Gaelic football?	• Yes, _____ • No

Appendix G: Study Details Prior to Survey

Study Information

This research is being conducted as part of a Research Masters in Athlone Institute of Technology. The purpose of this study is to investigate current levels of knowledge, awareness and willingness to implement an injury prevention programmes among Ladies Gaelic football coaches. We are also interested in investigating the current availability of medical attention and the presence of medical/healthcare professionals at all levels and age categories of Ladies Gaelic football.

There are no direct benefits for your participation in this research study, however, research gathered in this study may contribute to the further development of injury prevention programmes aiming to benefit Ladies Gaelic footballers. The information gathered from this questionnaire will be analysed and used by the research team to answer related research questions or for publication. However, at no point will any personal information or data be available.

Criteria for Participation

You should be a coach, aged 18 or older, and currently coaching a Ladies Gaelic football team at any level or age category, with at least one seasons experience coaching in Ladies Gaelic football

Potential Risks

Breach of Confidentiality: The risk of breach of confidentiality is minimal in this study. The information that you provide during this questionnaire will be kept confidential through the use of ID numbers. All electronic copies of data provided will be stored securely with encrypted passwords and any physical copies will be stored in a locked filing cabinet where only the primary researchers have access to the information. There will be no identifying information (e.g. name, the name of the team coached or date of birth) gathered from you as all data will be collected anonymously.

Internet Information Security: The security of questionnaire information that is gathered and stored in an online database cannot be guaranteed. Any information collected online from you may be intercepted, corrupted, lost or destroyed. In order to reduce any of the named risks, at the end of this study, all results will be downloaded from the online database and all responses will be permanently deleted from the online database.

Researcher Contact Information

If you have any further questions about this research study, please feel free to contact any of the researchers below;

Ms Emma Kavanagh Email: e.kavanagh@research.ait.ie

Dr Niamh Ní Chéilleachair Email: nnicheilleachair@ait.ie

Dr Siobhán O'Connor Email: siobhan.oconnor@dcu.ie

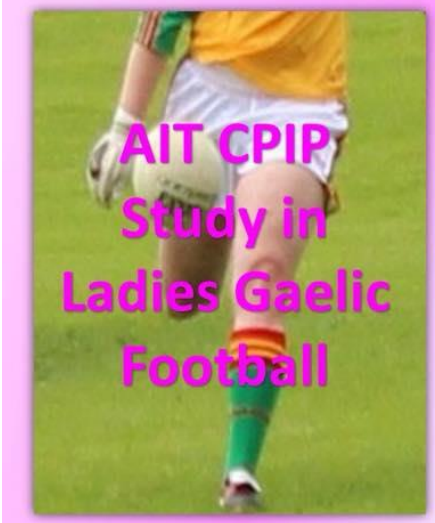
Your participation in this online questionnaire is greatly appreciated, however, participation is completely voluntary, and you are free to withdraw participation at any point throughout, by closing the questionnaire. By selecting agree to "I consent to participate" you are indicating that you meet the criteria for participation and that you have read the above information and are informed of the study requirements, benefits and potential risks, have been provided with contact details for the study researchers, and are freely volunteering to participate in this research study.

I consent to participate

□ Agree

□ Disagree

Appendix H: Online Recruitment Posters for Study 2 (Chapter 4)



****Ladies Gaelic Football Coaches Required****

Coaches with a minimum of 1-years experience in Ladies Gaelic football and over 18 years old required to complete an online survey on Injury Prevention in Ladies Gaelic football

> https://www.surveymonkey.com/r/AITCPIP <

Twitter: @AIT_CPIP_Study

Facebook: AIT CPIP-Research

AIT CPIP Study in Ladies Gaelic Football

>> Ladies Gaelic Football Coaches <<

Have your say on injury prevention in Ladies Gaelic football by completing our online survey

> https://www.surveymonkey.com/r/AITCPIP <

Twitter: @AIT_CPIP_Study

Facebook: AIT CPIP-Research