Epidemiology of injuries in Hurling: a prospective study 2007-2011

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Epidemiology of injuries in Hurling: a prospective study 2007-2011

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ABSTRACT

Objectives: Hurling is a stick handling game which, although native to Ireland, has international reach and presence. The aim of this study was to report incidence and type of injuries incurred by elite male hurling players over 5 consecutive playing seasons.

Design: Prospective cohort study.

Setting: Male inter-county elite sports teams, participating in the National GAA database, 2007-2011.

Participants: A total of 856 players in 25 county teams were enrolled.

Primary and secondary outcomes: Incidence, nature and mechanism of injury were recorded by team physicians or physiotherapists, to a secure online data collection portal. Time loss injury rates per 1000 h training and match play were calculated and injury proportions were expressed.

Results: In total 1030 injuries were registered, giving a rate of 1.2 injuries per player. These were sustained by 71% (n=608) of players. Injury incidence rate was 2.99 (95% CI 2.68 to 3.30) per 1000 training hours and 61.75 (56.75 to 66.75) per 1000 match hours. Direct player-to-player contact was recorded in 38.6% injuries, with sprinting (24.5%) and landing (13.7%) the next most commonly reported injury mechanisms. Median duration of time absent from training or games, where the player was able to return in the same season, was 12 days (range 2-127 days). The majority (68.3%) of injuries occurred in the lower limbs, with 18.6% in the upper limbs. The trunk and head/neck regions accounted for 8.6% and 4.1% injuries respectively. The distribution of injury type was significantly different ($p<0.001$) between upper and lower extremities; fractures (upper 36.1%, lower 1.5%), muscle strain (upper 5.2%, lower 45.8%).

Conclusions: These data provide stable, multi-annual data on injury patterns in hurling, identifying the most common injury problems. This is the first step in applying a systematic, theory-driven injury prevention model in the sport.

Strengths and limitations of this study:

- This is the first study to report on prospective surveillance of injury incidence over multiple playing seasons in the sport of hurling.
- The use of consensus definitions for injury enables comparison with incidence rates in other sports.

- Minor injuries that did not require time out from play were not captured in the injury definition.
- The sample was limited to the elite hurling population.

INTRODUCTION

The Gaelic Athletic Association (GAA) governs three amateur sporting codes; Gaelic Football, hurling and handball. Of these, hurling is perhaps the most unique, predominantly played in Ireland, but hurling clubs exist in Britain, Continental Europe, the USA, Canada and Australasia.[1] This reflects the Irish cultural diaspora, and with growing interest and adoption of these games, overseas branches of the governing body continue to expand. In hurling an ash stick, called a hurley or camán, is used to propel a hard leather ball, called a slíotar (diameter 69–72 mm, weight 110–120 g), (figure 1). Teams of 14 outfield players and a goalkeeper play on a rectangular grass pitch 145 m long and 90 m wide, for durations of 60-70 minutes per game.[2] The aim is to score by sending the ball between the opposition's goal posts. The ball is propelled through the air, at velocities up to 160 km/h, or along the ground; but kicking and hand passing are also permitted. [2] Other core skills include catching, blocking and lifting the ball with the stick, maintaining possession while running with the ball balanced or bounced on the stick and striking the ball while stationary or running.[2] Close player to player contact occurs in competing for the ball and in the tackle where dispossession is by means of contesting the opponents' attempts to strike the ball (blocking and hooking), or through a shoulder to shoulder body clash.[2]

The biomechanical demands of this game include jumping, landing, sprinting, rapid acceleration, deceleration, torsional movements and directional changes, as well as evasion through planting and cutting manoeuvers. Such actions pose risks for lower limb injury in particular, while the speed, intensity and force of the stick to stick, or stick to player contact give rise to direct traumatic injuries to the upper and lower limbs and trunk. Protective helmets and face guards have been mandatory for all grades of players since January 2010. [2]

To date, research into the epidemiology of injury in hurling has primarily focused on one body region or on injuries presenting to the hospital emergency department.[3-5] An early prospective study profiled injury in 74 players,[6] while a more recent paper describes hurling injury in 127 elite male players over one playing season.[7] Such a single snapshot view, however, does not account for season to season variation, thus the focus of this report is to extend the prospective surveillance period to 5 complete competitive seasons, as the first phase in the TRIPP[8] and Van Mechelen sport injury prevention models.[9] This will highlight key injuries and provide direction for future research into risk factors and prevention strategies. The aim of this study was therefore to describe incidence, mechanism, nature and severity of injury in elite male hurling over a 5 year time span. Differences between subgroups of players, based on age and playing position were also explored.

METHODS

The men's senior grade county representative hurling competition commences in January, running through to September. The season includes preliminary cup and shield competitions, followed by the National Senior Hurling League and culminating in the All Ireland Senior Hurling Championship. This study focuses on teams enrolled to a National GAA Injury Database during the years 2007 to 2011. The data collection system opened from 1st January, each year, with teams prospectively followed until eliminated from the competition. Data collection ceased for the off-season, following the All Ireland Hurling Final, recommencing in January of the following year.

The only inclusion criterion for participation was that the team had a qualified professional i.e., medical practitioner or chartered physiotherapist present at every match and training session who could verify injury diagnosis and classification as well as game and training exposure hours. Injury data were entered weekly by the team personnel through a dedicated secure web portal, recording the information onto the National GAA Injury Database. The player participants were male players selected for their representative county team and the total sample recruited was determined by the number of teams who volunteered to participate.

Ethical Approval

Only de-identified player data were recorded. Players were given an opportunity to decline inclusion of their data in the team reports. Anonymity was maintained and data protection assured in accordance with ethical approval received from the University Research Ethics Committee (LS-E-11-91-OMalley-Blake).

Definitions

Consensus injury definitions for hurling were agreed with the GAA Medical, Scientific and Player Welfare Committee, following a review of international literature. These have been applied both to hurling and Gaelic football, its sister sport and have already been described in detail.[7,10] An information pack regarding injury definition and classification was distributed to each participating medical team and these were also embedded into the user interface in the online data collection tool.

Injury was defined as a time loss injury i.e. "any injury that prevents a player from taking a full part in all training and match 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". This definition was initially informed by that employed by Brooks et al.[11] and conforms with the time-loss injury classification proposed in consensus statements for soccer and rugby union.[12,13] Recurrence of injury was defined as 'a reinjury to a previously injured region'. This was sub-classified according to duration since original injury into early recurrent (within 2 months), late recurrent (2 to 12 months) and delayed recurrent (>12 months). Return to full fitness was deemed to be when the player was able to take part in full training activities and be available for match selection. Other agreed definitions included classification into acute injuries, overuse injuries or chronic injuries similar to the description used by Van Mechelen et al.[9] Severity of injury was classified as mild (lasting up to 1 week), moderate (up to 4 weeks) or severe (>4 weeks), with these times similarly relating to absence from training or matchplay.[9]

Procedures

The initial enrollment of players required that anthropometric and demographic details, position of play, involvement in other levels of competition, past injury and use of protective equipment were recorded. Age was defined in years, as of January 1st of that year. Players joining or leaving the squad were added or deactivated as required throughout the season. Thereafter the database was open for entry of new or updating of existing injury diagnosis at any time, but weekly injury data entry was required at minimum, as were details of training and match-play exposure hours. For new injuries, the team doctor or physiotherapist recorded; player code, position of play, ground conditions, date of injury, mechanism of injury, body region, main tissue injured, side of injury, whether recurrent or new and clinical diagnosis. Progression details for current injured players were also required weekly, including update of the status i.e. whether still injured or date of return to partial or full fitness.

Analysis

The data were analysed by calculating injury rates per 1000 hours, with 95% confidence intervals (CI), using the substitution method.[14,15] Percentages with 95% CI were derived, using Wilson's method.[15] Risk Ratios (RR) and 95% CI were used to compare injury rates. Chi square tests compared the observed to expected proportions of injured players according to playing position and age group. Computations were made using PASW Statistics, Release Version 18.0.0,[16] VRP Injury Analysis Software[17] and the Confidence Interval Analysis Package v 2.1.2.[18]

RESULTS

Twenty five male hurling teams were recruited; 4 for 2007, 5 for 2008, 7 for 2009, 5 for 2010 and 4 for 2011, so between 12.5% and 22% of competing teams per year were enrolled over this period. A total of 856 player seasons were followed. The median squad size was 31 players (IQR = 28 to 33), with 15 of these taking to the field for each game. Mean age was 24.3 ±3.6 years (range 18 to 36; n=820). The duration of team enrolment ranged from 21 to 32 weeks (median=28) per season and so variable lengths of injury exposure were included in the incidence rate analysis.

Injury incidence

In total, 1030 injuries were recorded, giving a rate of 1.2 injuries per player registered. These injuries were sustained by 71% (608/1030; 95% CI 67.9 to 74.0) of the player cohort. Ninety two percent (948/1030) of injuries were attributed to single incidents occurring in the course of a match or training session, with the remaining 8% (82/1030) occurring insidiously, so these could not be identified as specific training or match injuries. Proportionately more injuries occurred in match play (56.9%) than training (35.1%) and the incidence rates per 1000 hours match play and training exposure are illustrated in table 1. The risk ratio for match play injury was 20.7 times that for training injury (96% CI 18.2 to 23.5).

Table 1. Injury incidence

	Exposure time (hours)	Number of injuries	% injuries	Injuries per 1000 hours	95% CI
Training injury	121119	362	35.1	2.99	2.68 to 3.30
Match injury	9490.5	586	56.9	61.75	56.75 to 66.75
Other injury		82	8.0		
Total injury		1030			
				Risk Ratio	**95% CI**
Injury risk ratio					
Match:Training				20.7	18.2 to 23.5

Where injuries were sustained on the field (n=952), the playing surface conditions were predominantly dry (80%, 95% CI 77.3 to 82.4). For injuries incurred during a competition match or structured training games, (n=702), the majority occurred in the third (32.3%, 95% CI 29.0 to 35.9) or fourth (33.2%, 95% CI 29.8 to 36.8) quarters of the session. In some cases of lower limb fracture and severe ligament disruption, the injured player did not return to the squad in that same season and so their time lost from play extended past the surveillance period. For those players whose injuries occurred and resolved in the same season, the median time loss for injury was 12 days, ranging from 2 to 127 days.

Playing position, age and injury

When observed injury classified by position of play was compared to expected injury, no statistically significant difference in injury proportions was noted between positions (χ^2 4.93, df=3, p=0.177), but it was interesting to see that the risk of injury was lower in goalkeepers (0.62/player registered), compared to outfield players, where the ratio of injury to player enrolled ranged from 0.99 to 1.04 (table 2). Age distribution was also compared between the injured players and the total group and similarly no significant difference in proportion of injury by age group was found (χ^2 = 4.10, df=3, p=0.25). In this case, however, a stepwise increase in injury incidence proportion was seen with ascending age. The youngest age group (18-20 years) had a ratio of injury to players of 0.63, rising to 1.16 in the over 30 age group (table 2).

Table 2. Distribution of injured players by position and age range

	% injured players	% distribution all players	Ratio	P value
Defender	41.6	40	1.04	
Forward	41.0	40	1.02	
Midfield	13.2	13.3	0.99	χ^2=4.93, df=3
Goalkeeper	4.2	6.7	0.62	p=0.177
18-20	14.5	17.8	0.82	
21-24	35.7	36.5	0.98	
25-29	39.2	36.5	1.07	χ^2=4.10, df=3
30+	10.6	9.1	1.16	p=0.250

Main type of injury and regional distribution of injury

Injuries classified by location are presented in table 3, while table 4 illustrates the main type and tissue injured, with sub-classification for upper and lower limbs. Overall, the majority of injuries occurred in the lower limbs (68.3%), with an incidence rate of 5.4/1000 h (95% CI 5.2 to 6.0). Thigh injuries were the most common injury location (22.9%). The knee (11.3%) and ankle (9.3%) were the joints most frequently injured in the lower limb, while the foot, toes and hip had a lower incidence. Injuries to the pelvis/groin region constituted 10.3% of injuries overall. Upper limb injuries accounted for 18.6% of the total, with an incidence rate of 1.5/1000 h (95% CI 1.3 to 1.7). Collectively, injury to the distal part of the upper limb (wrist, hand, fingers and thumb) constituted 10.3% of all injuries (95% CI 8.6 to 12.3), while the shoulder and upper arm sustained 7.1% of injuries.

Soft tissue injuries were foremost overall, with muscle (36.9%), ligament (17.6%), tendon (7.6%), general joint trauma (7.6%), contusions (7.5%) and haematomas (3.8%) accounting for over 8 in 10 of all injuries. Close to 9% of injuries were bone fractures (table 4). When the type of tissue injury was compared between the upper and lower limbs a significantly (p<0.001) different distribution was evident (table 4). There were proportionately more fractures (36.1%) in the upper limb than in the lower limb (1.5%). In contrast, muscle strain constituted 45.8% of lower limb injury but only 5.2% of injuries to the upper limb. The trunk and spine region, including ribs, sustained 8.6% injuries, while just over 4% of injuries were to the head and neck region.

Table 3. Injury details

	Total (n=1030)		95% CI
LL injuries	**703 (68.3)**		**65.3 to 71.0**
Pelvis &Groin	106 (10.3)		8.6 to 12.3
Hip	24 (2.3)		1.6 to 3.4
Thigh	236 (22.9)		20.4 to 25.6
Knee	123 (11.9)		10.1 to 14.1
Shin	30 (2.9)		2.0 to 4.1
Calf	52 (5.0)		3.9 to 6.6
Ankle	96 (9.3)		7.7 to 11.3
Foot & Toes	36 (3.5)		2.5 to 4.8
UL injuries	**191 (18.6)**		**16.3 to 21.0**
Shoulder & Upper Arm	73 (7.1)		5.7 to 8.8
Forearm	11 (1.1)		0.6 to 1.9
Elbow	1 (0.1)		0.0 to 0.05
Wrist	15 (1.5)		0.9 to 2.4
Hand & Fingers	71 (6.9)		5.5 to 8.6
Thumb	20 (1.9)		1.3 to 3.0
Head and Neck	**42 (4.1)**		**3.0 to 5.5**
Trunk & Spine	**89 (8.6)**		**7.1 to 10.5**
Unspecified	**5 (0.4)**		**0.2 to 1.2**
Mechanism of Injury			
Contact with another player	398 (38.6)		35.7 to 41.7
Sprinting	252 (24.5)		21.7 to 27.2
Landing	141 (13.7)		11.7 to 15.9
Turning	73 (7.1)		5.7 to 8.8
Kicking	3 (0.3)		0.1 to 0.9
Warm up	9 (0.9)		0.5 to 1.7
Other	143 (13.9)		11.9 to 16.1
Unspecified	11 (1.1)		0.6 to 1.9
Recurrent/New Injury			
New injury	832 (80.8)		77.9 to 82.7
Recurrent injury	180 (17.4)		15.3 to 19.9
Early recurrent (<2 months)		68 (8.2)*	6.5 to 10.3*
Late recurrent (2 to 12 months)		49 (5.9)*	4.5 to 7.8*
Delayed recurrent (> 12 months)		33 (5.3)*	4.0 to 7.1*
Unspecified	18 (1.8)		1.1 to 2.7
Injury type			
Acute	880 (85.4)		83.2 to 87.5
Chronic	41 (4.0)		2.9 to 5.4
Overuse	95 (9.2)		7.6 to 11.1
Unspecified	14 (1.4)		0.8 to 2.3

* Recurrent injury not sub-classified in 2007. Percentage and CI calculated from total injury 2008-11 (n=826)

Mechanism and nature of injury

Contact with another player was responsible for 38.6% of all injuries (table 3). Sprinting accounted for almost one quarter of injuries with landing (13.7%) and turning (7.1%) the other commonly reported injury mechanisms (table 3). While the majority (80.8%) were new injuries, 17.4% were recurrent in nature. The proportions attributed to early, late and delayed recurrence can be seen in table 3. Similarly the majority were acute injuries (85.2%), with overuse mechanisms reported in 9.2%.

Table 4. Main type of injury

	Total (n=1030)	95% CI	Upper Limb (n=191)	Lower Limb (n=703)	p value
Muscle strain	380 (36.9)	34.0 to 39.9	10 (5.2)	334 (47.5)	
Ligament sprain	181 (17.6)	15.4 to 20.0	46 (24.1)	120 (17.1)	
Bone fracture	86 (8.3)	6.8 to 10.2	69 (36.1)	11 (1.6)	
Tendon	78 (7.6)	6.1 to 9.4	5 (2.6)	71 (10.1)	
Joint general	78 (7.6)	6.1 to 9.4	18 (9.4)	37 (5.3)	
Bone contusion*	77 (7.5)	6.0 to 9.2	17 (8.9)	55 (7.8)	
Haematoma	39 (3.8)	2.8 to 5.1	8 (4.2)	27 (3.8)	
Skin	30 (2.9)	2.0 to 4.1	13 (6.8)	8 (1.1)	
Meniscus	23 (2.2)	1.5 to 3.3	--	23 (3.3)	χ^2=315.4, df=9
Other / Unspecified	58 (5.7)	4.3 to 7.1	5 (2.6)	17 (2.4)	p=0.

*periosteal and osseous trauma, no fracture

DISCUSSION

The results presented here provide for the first time a comprehensive injury profile of elite hurlers, through prospective surveillance over 5 consecutive seasons. The key findings are that the incidence rate of injury for matchplay is 61.75/1000 hours, which is almost 21 times that of training (2.99/ 1000 hours). The high relative risk of injury in hurling games compared to training sessions was previously identified in a study over one season.[7] This excess risk of injury from match play is commonly seen in sport, reflecting the intensity of competition. The current data show that aggregated injury rates are lower than those recorded in the single year snapshot taken in 2007, (102.5/1000 h (84.4 to 123.2) for matches and 5.3 (4.2 to 6.5) for training; RR=19.5 (14.8 to 25.6),[7] suggesting that incidence standardised for hours exposure has declined in subsequent years. Similarly, the incidence proportion of players is lower in the current pooled data than recorded in a single season (71% v 82%).[7] Multi year surveillance is thus recommended to account for such variability, providing more precise population estimates with tighter confidence intervals.

An injury rate of 1.2 per player registered was recorded and it can be extrapolated that for the average squad of 31 players, competing for the average duration of 28 weeks; 37 time loss injuries would occur. Of these 6 (17%) would be recurrent injuries; and each injury would on average necessitate 12 days absence from training or match play. These injuries would be sustained by 22 players, while 9 would escape uninjured. Outfield players are at higher risk of injury than the goalkeeper, but no notable position related differences were seen. Injury risk increases with age, a factor noted in other sports.[19,20] This may due to greater susceptibility to injury with ageing, while the increased likelihood of an older player having prior injury due to increased sport exposure may be a confounding factor.

The development of consensus statements for injury definition, methods for expressing risk and assurance of professional diagnosis of the injury sustained[12,13], allows direct comparison of time loss injury incidence between sporting codes, which formerly would not have been possible due to methodological heterogeneity. We previously contrasted one year injury data in hurling with that available for football field sports,[7] finding that injury in hurling match play was close to that of rugby union. The findings reported here however clearly place the full-body contact sports of rugby sevens and rugby union higher in the overall match play injury risk hierarchy (106 and 91 injuries per 1000 h respectively),[11,21] with soccer match play incidence lower than hurling, as reported both in the longstanding 11 year UEFA study (26.7 injuries per 1000 h),[22] or in a tournament situation (41.6 injuries per 1000 h).[23] It is difficult to make direct comparison with rugby league,[24] Australian Football League,[25] and American Football League[26] due to different injury definitions and reporting methods, but Gaelic football, the sister sport to hurling has a match play incidence rate (61.86/1000 h) directly equivalent to that of hurling.[10]

The most closely related field sports to hurling are shinty, another Gaelic stick handling game played in Scotland, lacrosse and field hockey. Research in shinty is limited to reports of injuries presenting at the emergency department[27] and there is a modest body of published descriptive epidemology in lacrosse and field hockey, with a focus on head, eye and hand injuries.[28-30] In men's intercollegiate lacrosse, a total incidence of 12.58 match injuries per 1000 athlete exposures (A-E) was reported,[28] but no comparable data for male field hockey is available. The nature and demands of bandy and ice hockey differ considerably from hurling, however it is interesting to make comparisons between these stick-handling sports. Timpka et al.[31] reported 7.3 injuries/1000 player game hours in 16 elite male bandy teams over one season and one study from an elite Japanese team, where a time loss injury definition was used, reported an injury rate of 11.7 injuries per 1000 game hours over 3 seasons.[32]

Upper limb injury

When comparing regional injuries as proportions of overall injury sustained, more reliable contrasts between sports can be made, although it must be acknowledged that more minor injuries, which did not require absence from training or games are not counted here due to the time-loss injury definition used. Thus it is not surprising that time-loss incidence rate here (1.5/1000 h), is markedly lower than the 19 injuries/1000 game hours recorded in a field hockey tournament where contusions were the most common injury.[33]

Almost 19% (95% CI 16.3 to 21.0) of all injuries in hurling were to the upper limb, the majority of which were fractures or sprains. The proportion of upper limb injury is comparable to NCAA men's lacrosse,[28] where the upper extremity accounted for 26.2% of game injuries and 16.9% of practice injuries, so it would appear that the frequency of upper extremity injury is similar in these sporting codes. Bowers et al.[29] compared hand injury in intercollegiate women's field hockey, women's lacrosse, men's ice hockey and men's lacrosse, finding significantly higher injury incidence in the ungloved hockey players compared to gloved athletes, a finding also reported by Mukherjee in field hockey.[33] Like field hockey, most hurling players play ungloved, so they too are at particular risk of contusion and laceration as well as carpal, metacarpal and phalangeal fracture as previously reported.[3,4] With all stick contact sports, the hand is susceptible to trauma due to direct blows from the opponent's stick or ball, but repetitive gripping, combined with forces transmitted to the hand and wrist may also contribute to injury. The use of an adhesive padded grip on the hurley stick itself is common, with the objective of enhanced grip, protection of the palm from friction and provision of some shock absorbency. Hurling gloves designed with dorsal padding and either low profile or absent palmar cover are also available to protect the player, without impeding grip, but unlike lacrosse and ice hockey, these are not prescribed as mandatory protective equipment. Hurling players can often continue to compete despite minor to moderate hand injury and so the extent and consequences of hand trauma may be under recognised. Further evaluation of these injuries is warranted and only longer-term follow up can identify the functional sequelae.

Lower limb injury

As previously reported in hurling,[6,7] lower limb injuries were dominant, with over two thirds of injuries being to the lower extremity in this cohort. It is also interesting to note that over 45% of injuries were attributed to non-contact mechanisms of sprinting, landing and turning. The thigh (22.9%) was the most common site and muscle (47.5%) the most common tissue injured in the lower limb. The proportion of lower limb injury may therefore be greater in hurling (68.3%) by comparison with approximately 48% of game and 59% of practice injuries recorded to the lower limb in men's collegiate lacrosse (Dick et al. 2007).[28] Dick et al.[28] reported that ankle ligament sprains ranged between 11.3% game and 16.4% practice injuries in men's lacrosse, contrasting with 9% (95% CI 7.7 to 11.3%) injuries overall to the ankle for hurling in the current study and 9% in an earlier report.[6] In hurling, the knee joint sustained just under 12% of injuries (95% CI 10.1 to 14.1%), while for male ice hockey, it has been reported that 10% (284/2828) of all injuries involved the knee ligaments[34] and that the knee was the most common game related (13.5%) lower extremity injury.[35] The data suggest that knee and ankle injuries do not vary widely between these sports.

Head, neck and trunk injury

Injury to the trunk, thoracic or lumbar spine represented 8.6% injury in hurling with most of these being soft tissue injuries and just over 4% of injuries were to the head and neck. When comparing to NCAA statistics, it was not unexpected that the proportion of head injury would be lower in hurling than in ice hockey (9% game, 5.3% practice),[34] given the chance of contact with another player, ice or boards in the ice rink. It was however surprising to see that hurling which allows overhead blocking and fielding of the ball, has a lower head injury incidence proportion than ladies field hockey (13% game injury, 3.4% practice injury),[36] while lacrosse also had a higher proportion (8.6% game injury, 3.6% practice injury) of head injury than our hurling cohort.[28]

One limitation with this study is that the results here pertain to elite teams, so the generalisation of these findings to other levels of participation should be done with caution. Due to the voluntary nature of the injury reporting system, there was limited ability to accurately follow up the more severe injuries that were ongoing at the end of the season, since not all teams re-registered for subsequent seasons. Tracking of individual players rather than teams would have facilitated complete follow up, but due to the de-identification of players as part of the approved ethical procedures, this was not possible in this timeframe. For more complete data collection and better response rates, greater engagement with the medical teams is a priority and a mandatory injury recording system could be considered.

CONCLUSIONS

This study, while reporting on an indigenous game provides novel and relevant findings for the wider sports medicine community, since hurling is represented in sporting populations outside of the country of origin. The data presented here are the results of a commitment by the GAA, an amateur sporting organisation to adopt a strategic and theory-based approach to the problem of player injury starting with measurement of incidence. This report identifies the extent and nature of injury in hurling through a long-term prospective design, providing reliable information on the incidence and type of injuries sustained. We can contrast these with sport internationally and learn from injury prevention strategies employed in other codes. Further opportunities exist to identify predictive factors and vulnerable subgroups of players, along with the ability to monitor changing trends in injury occurrence and to evaluate the effects of injury-prevention interventions.

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Contributorship Statement

Catherine Blake.

Responsible for conception, design, acquisition, analysis and interpretation of the data. Responsible for drafting, revision and approval of the manuscript. Accountable for all aspects of the work.

John C Murphy. Responsible for conception, design, acquisition and interpretation of the data. Substantial contribution to revision and approval of the manuscript. Accountable for all aspects of the work.

Edwenia O'Malley

Substantial contribution to acquisition, analysis and interpretation of the data. Substantial contribution to revision and approval of the manuscript. Accountable for all aspects of the work.

Conor Gissane.

Substantial contribution to the conception of the work and data analysis. Substantial contribution to revision and final approval of manuscript. Accountable for all aspects of the work.

Competing interests

None

Data Sharing Statement

Summary data from the injury database can be accessed through contacting the corresponding author.

REFERENCES

1. Gaelic Athletic Association. Overseas Units. GAA, Dublin 2014. http://www.gaa.ie/content/documents/publications/overseas/Overseas_Booklet_1001 10233815.pdf
2. Gaelic Athletic Association. GAA Official Guide Part 2. Playing Rules of Football and Hurling. , Dublin 2012. Available at http://www.gaa.ie/content/documents/publications/official_guides/Official_Guide_201 2_Part2.pdf
3. Flynn TH, Fennessy K, Horgan N et al. Ocular injury in hurling. *Br J Sports Med.* 2005;39(8):493-6; discussion 496. PMID: 16046328
4. Falvey E, McCrory P, Crowley B et al. Risk factors for hand injury in hurling: a cross-sectional study. *BMJ Open.* 2013;28;3(5). pii: e002634. doi: 10.1136/bmjopen-2013-002634. PubMed PMID:23793666
5. Kiely PD, Ashraff M, O'Grady P, Dawson MJ, O'Beirne JG. Hurling-related hand injuries. *Injury*. 2003;34(8):561-3. PubMed PMID: 12892715
6. Watson AW. Sports injuries in the game of hurling. A one-year prospective study. Am J Sports Med. 1996;24(3):323-8. PubMed PMID: 8734883.
7. Murphy JC, Gissane C, Blake C. Injury in elite county-level hurling: a prospective study. *Br J Sports Med*. 2012;46(2):138-42. doi:10.1136/bjsm.2010.072132.PMID: 20961917
8. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport.* 2006; 9 (1-2): 3-10 PMID: 19201766
9. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. Sports Med. 1992;14(2):82-99. PMID: 1509229
10. Murphy JC, O'Malley E, Gissane G et al. Incidence of Injury in Gaelic Football. A 4 year prospective study. *Am J Sports Med* 2012; 40(9): 2113-20 DOI: 10.1177/0363546512455315
11. Brooks JH, Fuller CW, Kemp SP et al. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *Br J Sports Med.* 2005;39(10):757-66. PMID: 16183774

12. Fuller CW, Ekstrand J, Junge A et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40(3):193-201. PMID: 16505073
13. Fuller CW, Molloy MG, Bagate C et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *Br J Sports Med.* 2007;41(5):328-31. PMID: 17452684
14. Daly L. Confidence limits made easy: Interval estimation using a substitution method. *Am J Epidem* 1998;147(8):783-790. PMID: 9554420
15. Campbell MJ, Daly LE, Machin D. Special topics. In *Statistics with Confidence 2nd ed.* Eds Altman DG, Machin D, Bryant TN, Gardiner MJ. BMJ Books, 2000 pp153-167
16. PASW Statistics version 18.0 IBM SPSS, Released August 2009. Chicago, IL, USA. http://www-01.ibm.com/software/analytics/spss/
17. VRP Injury Software. University of North Carolina Injury Prevention Research Centre), http://www.iprc.unc.edu/sportsinjurystatistics.shtml), accessed 10 July 2012
18. Bryant T. Confidence Interval Analysis Package version 2.1.2. 2000–2004. Southampton University of Southampton, 2000.
19. Arnason A, Sigurdsson SB, Gudmundsson A et al. Risk factors for injuries in football. *Am J Sports Med.* 2004;32(1 Suppl):5S-16S. PMID: 14754854.
20. Gabbe BJ, Bennell KL, Finch CF. Why are older Australian football players at greater risk of hamstring injury? *J Sci Med Sport.* 2006;9(4):327-33. PMID: 16678486.
21. Fuller CW, Taylor A, Molloy MG. Epidemiological study of injuries in international Rugby Sevens. Clin J Sport Med. 2010;20(3):179-84. PMID: 20445357.
22. Ekstrand J, Hägglund M, Kristenson K et al. Fewer ligament injuries but no preventive effect on muscle injuries and severe injuries: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47(12):732-37.PMID: 23813543.
23. Hagglund M, Waldan M, Ekstrand J. UEFA injury study -an injury audit of European Championships 2006 to 2008. *Br J Sports Med* 2009;43(7):483- 489. PMID: 19246461
24. King DA, Gissane C. Injuries in amateur rugby league matches in New Zealand: a comparison between a division 1 and a division 2 premier grade team. *Clin J Sport Med.* 2009;19:277–81. PMID: 19638820

25. Orchard J, Seward H, Orchard J. *21st Annual Australian Football League Injury Report, 2012*. Released 6th March 2013 http://www.afl.com.au/staticfile/AFL%20Tenant/AFL/Files/AFLInjuryReportFor2012.pdf

26. Dick R, Ferrara MS, Agel J et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):221-33. PMID: 17710170

27. McLean JG. A survey of shinty injuries in the highlands during 1987–88. *Br J Sports Med* 1989;23:179–82. PMID: 2620234

28. Dick R, Romani WA, Agel J et al. Descriptive epidemiology of collegiate men's lacrosse injuries: national collegiate athletic association injury surveillance system, 1988–1989 through 2003–2004. *J Athl Train* 2007;42(2):255–61. PMID: 17710174

29. Bowers AL, Baldwin KD, Sennett BJ. Athletic hand injuries in intercollegiate field hockey players. *Med Sci Sports Exerc.* 2008 Dec;40(12):2022-6. PMID: 18981949.

30. Murtaugh K. Field hockey injuries. *Curr Sports Med Rep.* 2009;8(5):267-72. PMID: 19741355.

31. Timpka T, Risto O, Borg K et al. Injury incidence in a men's elite bandy league: an epidemiological study of a full regular season. *Scand J Med Sci Sports.* 2007 Dec;17(6):636-40. PMID: 17331084

32. Kuzuhara K, Shimamoto H, Mase Y. Ice hockey injuries in a Japanese elite team: a 3-year prospective study. *J Athl Train* 2009;44:208–14. PMID: 19295967

33. Mukherjee S. Traumatic upper limb injuries during the Men's Field Hockey Junior World Cup 2009. Res Sports Med. 2013;21(4):318-29. doi: 10.1080/15438627.2013.825797. PMID: 24067118

34. Agel J, Harvey EJ. A 7 year review of men's and women's ice hockey injuries in the NCAA. *Can J Surg.* 2010;53(5):319-23. PMID:20858376

35. Agel J, Dompier TP, Dick R et al. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train. 2007 Apr-Jun;42(2):241-48. PMID: 17710172

36. Dick R, Hootman JM, Agel J et al. Descriptive epidemiology of collegiate women's field hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-89 through 2002-2003. J Athl Train. 2007;42(2):211-20. PMID 17710169

Figure 1. Hurley, slíotar and helmet
168x225mm (72 x 72 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 – 4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12, 14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Epidemiology of injuries in Hurling: a prospective study 2007-2011

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ABSTRACT

Objectives: Hurling is a stick handling game which, although native to Ireland, has international reach and presence. The aim of this study was to report incidence and type of injuries incurred by elite male hurling players over 5 consecutive playing seasons.

Design: Prospective cohort study.

Setting: Male inter-county elite sports teams, participating in the National GAA database, 2007-2011.

Participants: A total of 856 players in 25 county teams were enrolled.

Primary and secondary outcomes: Incidence, nature and mechanism of injury were recorded by team physicians or physiotherapists, to a secure online data collection portal. Time loss injury rates per 1000 h training and match play were calculated and injury proportions were expressed.

Results: In total 1030 injuries were registered, giving a rate of 1.2 injuries per player. These were sustained by 71% (n=608) of players. Injury incidence rate was 2.99 (95% CI 2.68 to 3.30) per 1000 training hours and 61.75 (56.75 to 66.75) per 1000 match hours. Direct player-to-player contact was recorded in 38.6% injuries, with sprinting (24.5%) and landing (13.7%) the next most commonly reported injury mechanisms. Median duration of time absent from training or games, where the player was able to return in the same season, was 12 days (range 2-127 days). The majority (68.3%) of injuries occurred in the lower limbs, with 18.6% in the upper limbs. The trunk and head/neck regions accounted for 8.6% and 4.1% injuries respectively. The distribution of injury type was significantly different (p<0.001) between upper and lower extremities; fractures (upper 36.1%, lower 1.5%), muscle strain (upper 5.2%, lower 45.8%).

Conclusions: These data provide stable, multi-annual data on injury patterns in hurling, identifying the most common injury problems. This is the first step in applying a systematic, theory-driven injury prevention model in the sport.

Strengths and limitations of this study:

- This is the first study to report on prospective surveillance of injury incidence over multiple playing seasons in the sport of hurling.
- The use of consensus definitions for injury enables comparison with incidence rates in other sports.

- Minor injuries that did not require time out from play were not captured in the injury definition.
- The sample was limited to the elite hurling population.

This work was supported by an unrestricted educational grant from the Gaelic Athletic Association.

INTRODUCTION

The Gaelic Athletic Association (GAA) governs three amateur sporting codes; Gaelic Football, hurling and handball. Of these, hurling is perhaps the most unique, predominantly played in Ireland, but hurling clubs exist in Britain, Continental Europe, the USA, Canada and Australasia.[1] This reflects the Irish cultural diaspora, and with growing interest and adoption of these games, overseas branches of the governing body continue to expand. In hurling an ash stick, called a hurley or camán, is used to propel a hard leather ball, called a slíotar (diameter 69–72 mm, weight 110–120 g), (figure 1). Teams of 14 outfield players and a goalkeeper play on a rectangular grass pitch 145 m long and 90 m wide, for durations of 60-70 minutes per game.[2] The aim is to score by sending the ball between the opposition's goal posts. The ball is propelled through the air, at velocities up to 160 km/h, or along the ground; but kicking and hand passing are also permitted. [2] Other core skills include catching, blocking and lifting the ball with the stick, maintaining possession while running with the ball balanced or bounced on the stick and striking the ball while stationary or running.[2] Close player to player contact occurs in competing for the ball and in the tackle where dispossession is by means of contesting the opponents' attempts to strike the ball (blocking and hooking), or through a shoulder to shoulder body clash.[2]

The biomechanical demands of this game include jumping, landing, sprinting, rapid acceleration, deceleration, torsional movements and directional changes, as well as evasion through planting and cutting manoeuvers. Such actions pose risks for lower limb injury in particular, while the speed, intensity and force of the stick to stick, or stick to player contact give rise to direct traumatic injuries to the upper and lower limbs and trunk. Protective helmets and face guards have been mandatory for all grades of players since January 2010. [2]

To date, research into the epidemiology of injury in hurling has primarily focused on one body region or on injuries presenting to the hospital emergency department.[3-5] An early prospective study profiled injury in 74 players,[6] while a more recent paper describes hurling injury in 127 elite male players over one playing season.[7] Such a single snapshot view, however, does not account for season to season variation, thus the focus of this report is to extend the prospective surveillance period to 5 complete competitive seasons, as the first phase in the TRIPP[8] and Van Mechelen sport injury prevention models.[9] These models define epidemiological research as the first step in injury prevention, allowing quantification of injury and associated risk factors. This then provides a platform for development, implementation and evaluation of injury prevention interventions, both in the context of controlled research and real-world sport environments. This study highlights key injuries and provides direction for future research into risk factors and prevention strategies. The aim was therefore to describe incidence, mechanism, nature and severity of injury in elite male hurling over a 5 year time span. Differences between subgroups of players, based on age and playing position were also explored.

METHODS

The men's senior grade county representative hurling competition commences in January, running through to September. The season includes preliminary cup and shield competitions, followed by the National Senior Hurling League and culminating in the All Ireland Senior Hurling Championship. This study focuses on teams enrolled to a National GAA Injury Database during the years 2007 to 2011. The data collection system opened from 1st January, each year, with teams prospectively followed until eliminated from the competition. Data collection ceased for the off-season, following the All Ireland Hurling Final, recommencing in January of the following year.

The only inclusion criterion for participation was that the team had a qualified professional i.e., medical practitioner or chartered physiotherapist present at every match and training session who could verify injury diagnosis and classification as well as game and training exposure hours. Injury data were entered weekly by the team personnel through a dedicated secure web portal, recording the information onto the National GAA Injury Database. The player participants were male players selected for their representative county team and the total sample recruited was determined by the number of teams who volunteered to participate.

Ethical Approval

Only de-identified player data were recorded. Players were given an opportunity to decline inclusion of their data in the team reports. Anonymity was maintained and data protection assured in accordance with ethical approval received from the University Research Ethics Committee (LS-E-11-91-OMalley-Blake).

Definitions

Consensus injury definitions for hurling were agreed with the GAA Medical, Scientific and Player Welfare Committee, following a review of international literature. These have been applied both to hurling and Gaelic football, its sister sport and have already been described in detail.[7,10] An information pack regarding injury definition and classification was distributed to each participating medical team and these were also embedded into the user interface in the online data collection tool.

Injury was defined as a time loss injury i.e. "any injury that prevents a player from taking a full part in all training and match 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". This definition was initially informed by that employed by Brooks et al.[11] and conforms with the time-loss injury classification proposed in consensus statements for soccer and rugby union.[12,13] Recurrence of injury was defined as 'a reinjury to a previously injured region'. This was sub-classified according to duration since original injury into early recurrent (within 2 months), late recurrent (2 to 12 months) and delayed recurrent (>12 months). Return to full fitness was deemed to be when the player was able to take part in full training activities and be available for match selection. Other agreed definitions included classification into acute injuries, overuse injuries or chronic injuries similar to the description used by Van Mechelen et al.[9] Severity of injury was classified as mild (lasting up to 1 week), moderate (up to 4 weeks) or severe (>4 weeks), with these times similarly relating to absence from training or match play.[9]

Procedures

The initial enrollment of players required that anthropometric and demographic details, position of play, involvement in other levels of competition, past injury and use of protective equipment were recorded. Age was defined in years, as of January 1st of that year. Players joining or leaving the squad were added or deactivated as required throughout the season. Thereafter the database was open for entry of new or updating of existing injury diagnosis at any time, but weekly injury data entry was required at minimum, as were details of training and match-play exposure hours. For new injuries, the team doctor or physiotherapist recorded; player code, position of play, ground conditions, date of injury, mechanism of injury, body region, main tissue injured, side of injury, whether recurrent or new and clinical diagnosis. Progression details for current injured players were also required weekly, including update of the status i.e. whether still injured or date of return to partial or full fitness.

Analysis

The data were analysed by calculating injury rates per 1000 hours, with 95% confidence intervals (CI), using the substitution method.[14,15] Percentages with 95% CI were derived, using Wilson's method.[15] Risk Ratios (RR) and 95% CI were used to compare injury rates. Chi square tests compared the observed to expected proportions of injured players according to playing position and age group. Computations were made using PASW Statistics, Release Version 18.0.0,[16] VRP Injury Analysis Software[17] and the Confidence Interval Analysis Package v 2.1.2.[18]

RESULTS

Twenty five male hurling teams were recruited; 4 for 2007, 5 for 2008, 7 for 2009, 5 for 2010 and 4 for 2011, so between 12.5% and 22% of competing teams per year were enrolled over this period. A total of 856 player seasons were followed and no player declined participation. The median squad size was 31 players (IQR = 28 to 33), with 15 of these taking to the field for each game. Mean age was 24.3 ±3.6 years (range 18 to 36; n=820). The duration of team enrolment ranged from 21 to 32 weeks (median=28) per season and so variable lengths of injury exposure were included in the incidence rate analysis.

Injury incidence

In total, 1030 injuries were recorded, giving a rate of 1.2 injuries per player registered. These injuries were sustained by 71% (608/1030; 95% CI 67.9 to 74.0) of the player cohort. Ninety two percent (948/1030) of injuries were attributed to single incidents occurring in the course of a match or training session, with the remaining 8% (82/1030) occurring insidiously, so these could not be identified as specific training or match injuries. Proportionately more injuries occurred in match play (56.9%) than training (35.1%) and the incidence rates per 1000 hours match play and training exposure are illustrated in table 1. The risk ratio for match play injury was 20.7 times that for training injury (96% CI 18.2 to 23.5).

Table 1. Injury incidence

	Exposure time (hours)	Number of injuries	% injuries	Injuries per 1000 hours	95% CI
Training injury	121119	362	35.1	2.99	2.68 to 3.30
Match injury	9490.5	586	56.9	61.75	56.75 to 66.75
Other injury		82	8.0		
Total injury		1030			
				Risk Ratio	**95% CI**
Injury risk ratio					
Match:Training				20.7	18.2 to 23.5

Where injuries were sustained on the field (n=952), the playing surface conditions were predominantly dry (80%, 95% CI 77.3 to 82.4). For injuries incurred during a competition match or structured training games, (n=702), the majority occurred in the third (32.3%, 95% CI 29.0 to 35.9) or fourth (33.2%, 95% CI 29.8 to 36.8) quarters of the session. In some cases of lower limb fracture and severe ligament disruption, the injured player did not return to the squad in that same season and so their time lost from play extended past the surveillance period. For those players whose injuries occurred and resolved in the same season, the median time loss for injury was 12 days, ranging from 2 to 127 days.

Playing position, age and injury

When observed injury classified by position of play was compared to expected injury, no statistically significant difference in injury proportions was noted between positions (χ^2 4.93, df=3, p=0.177), but it was interesting to see that the risk of injury was lower in goalkeepers

(0.62/player registered), compared to outfield players, where the ratio of injury to player enrolled ranged from 0.99 to 1.04 (table 2). Age distribution was also compared between the injured players and the total group and similarly no significant difference in proportion of injury by age group was found (χ^2 = 4.10, df=3, p=0.25). In this case, however, a stepwise increase in injury incidence proportion was seen with ascending age. The youngest age group (18-20 years) had a ratio of injury to players of 0.63, rising to 1.16 in the over 30 age group (table 2).

Table 2. Distribution of injured players by position and age range

	% injured players	% distribution all players	Ratio	P value
Defender	41.6	40	1.04	
Forward	41.0	40	1.02	
Midfield	13.2	13.3	0.99	χ^2=4.93, df=3
Goalkeeper	4.2	6.7	0.62	p=0.177
18-20	14.5	17.8	0.82	
21-24	35.7	36.5	0.98	
25-29	39.2	36.5	1.07	χ^2=4.10, df=3
30+	10.6	9.1	1.16	p=0.250

Main type of injury and regional distribution of injury

Injuries classified by location are presented in table 3, while table 4 illustrates the main type and tissue injured, with sub-classification for upper and lower limbs. Overall, the majority of injuries occurred in the lower limbs (68.3%), with an incidence rate of 5.4/1000 h (95% CI 5.2 to 6.0). Thigh injuries were the most common injury location (22.9%). The knee (11.3%) and ankle (9.3%) were the joints most frequently injured in the lower limb, while the foot, toes and hip had a lower incidence. Injuries to the pelvis/groin region constituted 10.3% of injuries overall. Upper limb injuries accounted for 18.6% of the total, with an incidence rate of 1.5/1000 h (95% CI 1.3 to 1.7). Collectively, injury to the distal part of the upper limb (wrist, hand, fingers and thumb) constituted 10.3% of all injuries (95% CI 8.6 to 12.3), while the shoulder and upper arm sustained 7.1% of injuries.

Soft tissue injuries were foremost overall, with muscle (36.9%), ligament (17.6%), tendon (7.6%), general joint trauma (7.6%), contusions (7.5%) and haematomas (3.8%) accounting for over 8 in 10 of all injuries. Close to 9% of injuries were bone fractures (table 4). When the type of tissue injury was compared between the upper and lower limbs a significantly (p<0.001) different distribution was evident (table 4). There were proportionately more fractures (36.1%) in the upper limb than in the lower limb (1.5%). In contrast, muscle strain constituted 45.8% of lower limb injury but only 5.2% of injuries to the upper limb. The trunk and spine region, including ribs, sustained 8.6% injuries, while just over 4% of injuries were to the head and neck region.

Mechanism and nature of injury

Contact with another player was responsible for 38.6% of all injuries (table 3). Sprinting accounted for almost one quarter of injuries with landing (13.7%) and turning (7.1%) the other commonly reported injury mechanisms (table 3). While the majority (80.8%) were new injuries, 17.4% were recurrent in nature. The proportions attributed to early, late and delayed recurrence can be seen in table 3. Similarly the majority were acute injuries (85.2%), with overuse mechanisms reported in 9.2%.

Table 3. Injury details

	Total (n=1030)		95% CI
LL injuries	**703 (68.3)**		**65.3 to 71.0**
Pelvis &Groin	106 (10.3)		8.6 to 12.3
Hip	24 (2.3)		1.6 to 3.4
Thigh	236 (22.9)		20.4 to 25.6
Knee	123 (11.9)		10.1 to 14.1
Shin	30 (2.9)		2.0 to 4.1
Calf	52 (5.0)		3.9 to 6.6
Ankle	96 (9.3)		7.7 to 11.3
Foot & Toes	36 (3.5)		2.5 to 4.8
UL injuries	**191 (18.6)**		**16.3 to 21.0**
Shoulder & Upper Arm	73 (7.1)		5.7 to 8.8
Forearm	11 (1.1)		0.6 to 1.9
Elbow	1 (0.1)		0.0 to 0.05
Wrist	15 (1.5)		0.9 to 2.4
Hand & Fingers	71 (6.9)		5.5 to 8.6
Thumb	20 (1.9)		1.3 to 3.0
Head and Neck	**42 (4.1)**		**3.0 to 5.5**
Trunk & Spine	**89 (8.6)**		**7.1 to 10.5**
Unspecified	**5 (0.4)**		**0.2 to 1.2**
Mechanism of Injury			
Contact with another player	398 (38.6)		35.7 to 41.7
Sprinting	252 (24.5)		21.7 to 27.2
Landing	141 (13.7)		11.7 to 15.9
Turning	73 (7.1)		5.7 to 8.8
Kicking	3 (0.3)		0.1 to 0.9
Warm up	9 (0.9)		0.5 to 1.7
Other	143 (13.9)		11.9 to 16.1
Unspecified	11 (1.1)		0.6 to 1.9
Recurrent/New Injury			
New injury	832 (80.8)		77.9 to 82.7
Recurrent injury	180 (17.4)		15.3 to 19.9
Early recurrent (<2 months)		68 (8.2)*	6.5 to 10.3*
Late recurrent (2 to 12 months)		49 (5.9)*	4.5 to 7.8*
Delayed recurrent (> 12 months)		33 (5.3)*	4.0 to 7.1*
Unspecified	18 (1.8)		1.1 to 2.7
Injury type			
Acute	880 (85.4)		83.2 to 87.5
Chronic	41 (4.0)		2.9 to 5.4
Overuse	95 (9.2)		7.6 to 11.1
Unspecified	14 (1.4)		0.8 to 2.3

* Recurrent injury not sub-classified in 2007. Percentage and CI calculated from total injury 2008-11 (n=826)

Table 4. Main type of injury

	Total (n=1030)	95% CI	Upper Limb (n=191)	Lower Limb (n=703)	p value
Muscle strain	380 (36.9)	34.0 to 39.9	10 (5.2)	334 (47.5)	
Ligament sprain	181 (17.6)	15.4 to 20.0	46 (24.1)	120 (17.1)	
Bone fracture	86 (8.3)	6.8 to 10.2	69 (36.1)	11 (1.6)	
Tendon	78 (7.6)	6.1 to 9.4	5 (2.6)	71 (10.1)	
Joint general	78 (7.6)	6.1 to 9.4	18 (9.4)	37 (5.3)	
Bone contusion*	77 (7.5)	6.0 to 9.2	17 (8.9)	55 (7.8)	
Haematoma	39 (3.8)	2.8 to 5.1	8 (4.2)	27 (3.8)	
Skin	30 (2.9)	2.0 to 4.1	13 (6.8)	8 (1.1)	
Meniscus	23 (2.2)	1.5 to 3.3	--	23 (3.3)	χ^2=315.4, df=9
Other / Unspecified	58 (5.7)	4.3 to 7.1	5 (2.6)	17 (2.4)	p<0.0001

*periosteal and osseous trauma, no fracture

DISCUSSION

The results presented here provide for the first time a comprehensive injury profile of elite hurlers, through prospective surveillance over 5 consecutive seasons. The key findings are that the incidence rate of injury for match play is 61.75/1000 hours, which is almost 21 times that of training (2.99/ 1000 hours), mirroring previous research over one season.[7] This excess risk of injury from match play is commonly seen in field sports, including Gaelic football (61.86/1000h match v 4.05/1000h training)[10], and soccer (26.6/1000h match v 4.0/1000h training) [19], reflecting the intensity of competition. However, it is notable that hurling demonstrates the highest relative risk of injury for matches versus training, amongst these sports.

The current data show that aggregated hurling injury rates are lower than those recorded in the single year snapshot taken in 2007, (102.5/1000 h (84.4 to 123.2) for matches and 5.3 (4.2 to 6.5) for training; RR=19.5 (14.8 to 25.6),[7] suggesting that incidence standardised for hours exposure has declined in subsequent years. Similarly, the incidence proportion of players is lower in the current pooled data than recorded in a single season (71% v 82%).[7] Multi-year surveillance is thus recommended to account for such variability, providing more precise population estimates with tighter confidence intervals.

An injury rate of 1.2 per player registered was recorded and it can be extrapolated that for the average squad of 31 players, competing for the average duration of 28 weeks; 37 time loss injuries would occur. Of these 6 (17%) would be recurrent injuries; and each injury would on average necessitate 12 days absence from training or match play. These injuries would be sustained by 22 players, while 9 would escape uninjured. Outfield players are at higher risk of injury than the goalkeeper, but no notable position related differences were seen. Injury risk increases with age, a factor noted in other sports.[20,21] This may due to greater susceptibility to injury with ageing, while the increased likelihood of an older player having prior injury due to increased sport exposure may be a confounding factor.

The development of consensus statements for injury definition, methods for expressing risk and assurance of professional diagnosis of the injury sustained[12,13], allows direct comparison of time loss injury incidence between sporting codes, which formerly would not have been possible due to methodological heterogeneity. We previously contrasted one year injury data in hurling with that available for football field sports,[7] finding that injury in hurling match play was close to that of rugby union. The findings reported here however clearly place the full-body contact sports of rugby sevens and rugby union higher in the overall match play injury risk hierarchy (106 and 91 injuries per 1000 h respectively),[11,22] with soccer match play incidence lower than hurling, as reported in the longstanding UEFA study (26.6-27.5 injuries per 1000 h),[19, 23]. It is difficult to make direct comparison with rugby league,[24] Australian Football League,[25] and American Football League[26] due to different injury definitions and reporting methods, but Gaelic football, the sister sport to hurling has a match play incidence rate (61.86/1000 h) directly equivalent to that of hurling.[10]

The most closely related field sports to hurling are shinty, another Gaelic stick handling game played in Scotland, lacrosse and field hockey. Research in shinty is limited to reports of injuries presenting at the emergency department[27] and there is a modest body of published descriptive epidemology in lacrosse and field hockey, with a focus on head, eye and hand injuries.[28-30] In men's intercollegiate lacrosse, a total incidence of 12.58 match injuries per 1000 athlete exposures (A-E) was reported,[28] but no comparable data for male field hockey is available. The nature and demands of bandy and ice hockey differ considerably from hurling, however it is interesting to make comparisons between these stick-handling sports. Timpka et al.[31] reported 7.3 injuries/1000 player game hours in 16 elite male bandy teams over one season and one study from an elite Japanese team, where a time loss injury definition was used, reported an injury rate of 11.7 injuries per 1000 game hours over 3 seasons.[32]

Upper limb injury

When comparing regional injuries as proportions of overall injury sustained, more reliable contrasts between sports can be made, although it must be acknowledged that more minor injuries, which did not require absence from training or games are not counted here due to the time-loss injury definition used. Thus it is not surprising that time-loss incidence rate here (1.5/1000 h), is markedly lower than the 19 injuries/1000 game hours recorded in a field hockey tournament where contusions were the most common injury.[33]

Almost 19% (95% CI 16.3 to 21.0) of all injuries in hurling were to the upper limb, the majority of which were fractures or sprains. The proportion of upper limb injury is comparable to NCAA men's lacrosse,[28] where the upper extremity accounted for 26.2% of game injuries and 16.9% of practice injuries, so it would appear that the frequency of upper extremity injury is similar in these sporting codes. Bowers et al.[29] compared hand injury in intercollegiate women's field hockey, women's lacrosse, men's ice hockey and men's lacrosse, finding significantly higher injury incidence in the ungloved hockey players compared to gloved athletes, a finding also reported by Mukherjee in field hockey.[33] Like field hockey, most hurling players play ungloved, so they too are at particular risk of contusion and laceration as well as carpal, metacarpal and phalangeal fracture as previously reported.[3,4] With all stick contact sports, the hand is susceptible to trauma due to direct blows from the opponent's stick or ball, but repetitive gripping, combined with forces transmitted to the hand and wrist may also contribute to injury. The use of an adhesive padded grip on the hurley stick itself is common, with the objective of enhanced grip, protection of the palm from friction and provision of some shock absorbency. Hurling gloves designed with dorsal padding and either low profile or absent palmar cover are also available to protect the player, without impeding grip, but unlike lacrosse and ice hockey, these are not prescribed as mandatory protective equipment. Hurling players can often continue to compete despite minor to moderate hand injury and so the extent and consequences of hand trauma may be under recognised. Further evaluation of these injuries is warranted and only longer-term follow up can identify the functional sequelae.

Lower limb injury

As previously reported in hurling,[6,7] lower limb injuries were dominant, with over two thirds of injuries being to the lower extremity in this cohort. It is also interesting to note that over 45% of injuries were attributed to non-contact mechanisms of sprinting, landing and turning. The thigh (22.9%) was the most common site and muscle (47.5%) the most common tissue injured in the lower limb. The proportion of lower limb injury may therefore be greater in hurling (68.3%) by comparison with approximately 48% of game and 59% of practice injuries recorded to the lower limb in men's collegiate lacrosse (Dick et al. 2007).[28] Dick et al.[28] reported that ankle ligament sprains ranged between 11.3% game and 16.4% practice injuries in men's lacrosse, contrasting with 9% (95% CI 7.7 to 11.3%) injuries overall to the ankle for hurling in the current study and 9% in an earlier report.[6] In hurling, the knee joint sustained just under 12% of injuries (95% CI 10.1 to 14.1%), while for male ice hockey, it has been reported that 10% (284/2828) of all injuries involved the knee ligaments[34] and that the knee was the most common game related (13.5%) lower extremity injury.[35] The data suggest that knee and ankle injuries do not vary widely between these sports.

Head, neck and trunk injury

Injury to the trunk, thoracic or lumbar spine represented 8.6% injury in hurling with most of these being soft tissue injuries and just over 4% of injuries were to the head and neck. When comparing to NCAA statistics, it was not unexpected that the proportion of head injury would be lower in hurling than in ice hockey (9% game, 5.3% practice),[34] given the chance of contact with another player, ice or boards in the ice rink. It was however surprising to see that hurling which allows overhead blocking and fielding of the ball, has a lower head injury incidence proportion than ladies field hockey (13% game injury, 3.4% practice injury),[36] while lacrosse also had a higher proportion (8.6% game injury, 3.6% practice injury) of head injury than our hurling cohort.[28] Further data collection over additional seasons is planned to allow systematic evaluation of subtypes of head injury and trends over time. However it is of note that no ocular injury was recorded in this elite cohort since the introduction of mandatory helmets with faceguards in 2010.

One limitation with this study is that the results here pertain to elite teams, so the generalisation of these findings to other levels of participation should be done with caution. Due to the voluntary nature of the injury reporting system, there was limited ability to accurately follow up the more severe injuries that were ongoing at the end of the season, since not all teams re-registered for subsequent seasons. Tracking of individual players rather than teams would have facilitated complete follow up, but due to the de-identification of players as part of the approved ethical procedures, this was not possible in this timeframe. For more complete data collection and better response rates, greater engagement with the medical teams is a priority and a mandatory injury recording system could be considered.

CONCLUSIONS

This study, while reporting on an indigenous game provides novel and relevant findings for the wider sports medicine community, since hurling is represented in sporting populations outside of the country of origin. The data presented here are the results of a commitment by the GAA, an amateur sporting organisation to adopt a strategic and theory-based approach to the problem of player injury starting with measurement of incidence. This report identifies the extent and nature of injury in hurling through a long-term prospective design, providing reliable information on the incidence and type of injuries sustained. We can contrast these with sport internationally and learn from injury prevention strategies employed in other codes. Ongoing injury surveillance, as described here, provides a platform to identify predictive factors and vulnerable subgroups of players, along with capacity to monitor changing trends in injury and to evaluate the effects of injury-prevention interventions.

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Data sharing

Summary data from the injury database can be accessed through contacting the corresponding author.

Competing Interests

None

Contributorship

Catherine Blake.

Responsible for conception, design, acquisition, analysis and interpretation of the data. Responsible for drafting, revision and approval of the manuscript. Accountable for all aspects of the work.

Edwenia O'Malley

Substantial contribution to acquisition, analysis and interpretation of the data. Substantial contribution to revision and approval of the manuscript. Accountable for all aspects of the work.

Conor Gissane.

Substantial contribution to the conception of the work and data analysis. Substantial contribution to revision and final approval of manuscript. Accountable for all aspects of the work.

John C Murphy. Responsible for conception, design, acquisition and interpretation of the data. Substantial contribution to revision and approval of the manuscript. Accountable for all aspects of the work.

REFERENCES

1. Gaelic Athletic Association. Overseas Units. GAA, Dublin 2014. http://www.gaa.ie/content/documents/publications/overseas/Overseas_Booklet_1001 10233815.pdf
2. Gaelic Athletic Association. GAA Official Guide Part 2. Playing Rules of Football and Hurling. , Dublin 2012. Available at http://www.gaa.ie/content/documents/publications/official_guides/Official_Guide_201 2_Part2.pdf
3. Flynn TH, Fennessy K, Horgan N et al. Ocular injury in hurling. *Br J Sports Med.* 2005;39(8):493-6; discussion 496. PMID: 16046328
4. Falvey E, McCrory P, Crowley B et al. Risk factors for hand injury in hurling: a cross-sectional study. *BMJ Open.* 2013;28;3(5). pii: e002634. doi: 10.1136/bmjopen-2013-002634. PMID:23793666
5. Kiely PD, Ashraff M, O'Grady P, Dawson MJ, O'Beirne JG. Hurling-related hand injuries. *Injury*. 2003;34(8):561-3. PMID: 12892715
6. Watson AW. Sports injuries in the game of hurling. A one-year prospective study. Am J Sports Med. 1996;24(3):323-8. PMID: 8734883.
7. Murphy JC, Gissane C, Blake C. Injury in elite county-level hurling: a prospective study. *Br J Sports Med*. 2012;46(2):138-42. doi:10.1136/bjsm.2010.072132.PMID: 20961917
8. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport.* 2006; 9 (1-2): 3-10 PMID: 19201766
9. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. Sports Med. 1992;14(2):82-99. PMID: 1509229
10. Murphy JC, O'Malley E, Gissane G et al. Incidence of Injury in Gaelic Football. A 4 year prospective study. *Am J Sports Med* 2012; 40(9): 2113-20 DOI: 10.1177/0363546512455315
11. Brooks JH, Fuller CW, Kemp SP et al. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *Br J Sports Med.* 2005;39(10):757-66. PMID: 16183774

12. Fuller CW, Ekstrand J, Junge A et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40(3):193-201. PMID: 16505073
13. Fuller CW, Molloy MG, Bagate C et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *Br J Sports Med.* 2007;41(5):328-31. PMID: 17452684
14. Daly L. Confidence limits made easy: Interval estimation using a substitution method. *Am J Epidem* 1998;147(8):783-790. PMID: 9554420
15. Campbell MJ, Daly LE, Machin D. Special topics. In *Statistics with Confidence 2nd ed.* Eds Altman DG, Machin D, Bryant TN, Gardiner MJ. BMJ Books, 2000 pp153-167
16. PASW Statistics version 18.0 IBM SPSS, Released August 2009. Chicago, IL, USA. http://www-01.ibm.com/software/analytics/spss/
17. VRP Injury Software. University of North Carolina Injury Prevention Research Centre), http://www.iprc.unc.edu/sportsinjurystatistics.shtml), accessed 10 July 2012
18. Bryant T. Confidence Interval Analysis Package version 2.1.2. 2000–2004. Southampton University of Southampton, 2000.
19. Hägglund M, Waldén M, Magnusson H et al. Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA Champions League injury study. Br J Sports Med. 2013;47(12):738-42. PMID: 23645832.
20. Arnason A, Sigurdsson SB, Gudmundsson A et al. Risk factors for injuries in football. *Am J Sports Med.* 2004;32(1 Suppl):5S-16S. PMID: 14754854.
21. Gabbe BJ, Bennell KL, Finch CF. Why are older Australian football players at greater risk of hamstring injury? *J Sci Med Sport.* 2006;9(4):327-33. PMID: 16678486.
22. Fuller CW, Taylor A, Molloy MG. Epidemiological study of injuries in international Rugby Sevens. Clin J Sport Med. 2010;20(3):179-84. PMID: 20445357.
23. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football: the UEFA injury study. Br J Sports Med. 2011;45(7):553-8. PMID:19553225
24. King DA, Gissane C. Injuries in amateur rugby league matches in New Zealand: a comparison between a division 1 and a division 2 premier grade team. *Clin J Sport Med.* 2009;19:277–81. PMID: 19638820

25. Orchard J, Seward H, Orchard J. *21st Annual Australian Football League Injury Report, 2012*. Released 6th March 2013 http://www.afl.com.au/staticfile/AFL%20Tenant/AFL/Files/AFLInjuryReportFor2012.pdf
26. Dick R, Ferrara MS, Agel J et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):221-33. PMID: 17710170
27. McLean JG. A survey of shinty injuries in the highlands during 1987–88. *Br J Sports Med* 1989;23:179–82. PMID: 2620234
28. Dick R, Romani WA, Agel J et al. Descriptive epidemiology of collegiate men's lacrosse injuries: national collegiate athletic association injury surveillance system, 1988–1989 through 2003–2004. *J Athl Train* 2007;42(2):255–61. PMID: 17710174
29. Bowers AL, Baldwin KD, Sennett BJ. Athletic hand injuries in intercollegiate field hockey players. *Med Sci Sports Exerc.* 2008 Dec;40(12):2022-6. PMID: 18981949.
30. Murtaugh K. Field hockey injuries. *Curr Sports Med Rep.* 2009;8(5):267-72. PMID: 19741355.
31. Timpka T, Risto O, Borg K et al. Injury incidence in a men's elite bandy league: an epidemiological study of a full regular season. *Scand J Med Sci Sports.* 2007 Dec;17(6):636-40. PMID: 17331084
32. Kuzuhara K, Shimamoto H, Mase Y. Ice hockey injuries in a Japanese elite team: a 3-year prospective study. *J Athl Train* 2009;44:208–14. PMID: 19295967
33. Mukherjee S. Traumatic upper limb injuries during the Men's Field Hockey Junior World Cup 2009. Res Sports Med. 2013;21(4):318-29. doi: 10.1080/15438627.2013.825797. PMID: 24067118
34. Agel J, Harvey EJ. A 7 year review of men's and women's ice hockey injuries in the NCAA. *Can J Surg.* 2010;53(5):319-23. PMID:20858376
35. Agel J, Dompier TP, Dick R et al. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train. 2007 Apr-Jun;42(2):241-48. PMID: 17710172
36. Dick R, Hootman JM, Agel J et al. Descriptive epidemiology of collegiate women's field hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-89 through 2002-2003. J Athl Train. 2007;42(2):211-20. PMID 17710169

Epidemiology of injuries in Hurling: a prospective study 2007-2011

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ABSTRACT

Objectives: Hurling is a stick handling game which, although native to Ireland, has international reach and presence. The aim of this study was to report incidence and type of injuries incurred by elite male hurling players over 5 consecutive playing seasons.

Design: Prospective cohort study.

Setting: Male inter-county elite sports teams, participating in the National GAA database, 2007-2011.

Participants: A total of 856 players in 25 county teams were enrolled.

Primary and secondary outcomes: Incidence, nature and mechanism of injury were recorded by team physicians or physiotherapists, to a secure online data collection portal. Time loss injury rates per 1000 h training and match play were calculated and injury proportions were expressed.

Results: In total 1030 injuries were registered, giving a rate of 1.2 injuries per player. These were sustained by 71% (n=608) of players. Injury incidence rate was 2.99 (95% CI 2.68 to 3.30) per 1000 training hours and 61.75 (56.75 to 66.75) per 1000 match hours. Direct player-to-player contact was recorded in 38.6% injuries, with sprinting (24.5%) and landing (13.7%) the next most commonly reported injury mechanisms. Median duration of time absent from training or games, where the player was able to return in the same season, was 12 days (range 2-127 days). The majority (68.3%) of injuries occurred in the lower limbs, with 18.6% in the upper limbs. The trunk and head/neck regions accounted for 8.6% and 4.1% injuries respectively. The distribution of injury type was significantly different ($p<0.001$) between upper and lower extremities; fractures (upper 36.1%, lower 1.5%), muscle strain (upper 5.2%, lower 45.8%).

Conclusions: These data provide stable, multi-annual data on injury patterns in hurling, identifying the most common injury problems. This is the first step in applying a systematic, theory-driven injury prevention model in the sport.

Strengths and limitations of this study:

- This is the first study to report on prospective surveillance of injury incidence over multiple playing seasons in the sport of hurling.
- The use of consensus definitions for injury enables comparison with incidence rates in other sports.

- Minor injuries that did not require time out from play were not captured in the injury definition.
- The sample was limited to the elite hurling population.

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INTRODUCTION

The Gaelic Athletic Association (GAA) governs three amateur sporting codes; Gaelic Football, hurling and handball. Of these, hurling is perhaps the most unique, predominantly played in Ireland, but hurling clubs exist in Britain, Continental Europe, the USA, Canada and Australasia.[1] This reflects the Irish cultural diaspora, and with growing interest and adoption of these games, overseas branches of the governing body continue to expand. In hurling an ash stick, called a hurley or camán, is used to propel a hard leather ball, called a slíotar (diameter 69–72 mm, weight 110–120 g), (figure 1). Teams of 14 outfield players and a goalkeeper play on a rectangular grass pitch 145 m long and 90 m wide, for durations of 60-70 minutes per game.[2] The aim is to score by sending the ball between the opposition's goal posts. The ball is propelled through the air, at velocities up to 160 km/h, or along the ground; but kicking and hand passing are also permitted. [2] Other core skills include catching, blocking and lifting the ball with the stick, maintaining possession while running with the ball balanced or bounced on the stick and striking the ball while stationary or running.[2] Close player to player contact occurs in competing for the ball and in the tackle where dispossession is by means of contesting the opponents' attempts to strike the ball (blocking and hooking), or through a shoulder to shoulder body clash.[2]

The biomechanical demands of this game include jumping, landing, sprinting, rapid acceleration, deceleration, torsional movements and directional changes, as well as evasion through planting and cutting manoeuvers. Such actions pose risks for lower limb injury in particular, while the speed, intensity and force of the stick to stick, or stick to player contact give rise to direct traumatic injuries to the upper and lower limbs and trunk. Protective helmets and face guards have been mandatory for all grades of players since January 2010. [2]

To date, research into the epidemiology of injury in hurling has primarily focused on one body region or on injuries presenting to the hospital emergency department.[3-5] An early prospective study profiled injury in 74 players,[6] while a more recent paper describes hurling injury in 127 elite male players over one playing season.[7] Such a single snapshot view, however, does not account for season to season variation, thus the focus of this report is to extend the prospective surveillance period to 5 complete competitive seasons, as the first phase in the TRIPP[8] and Van Mechelen sport injury prevention models.[9] These models define epidemiological research as the first step in injury prevention, allowing quantification of injury and associated risk factors. This then provides a platform for development, implementation and evaluation of injury prevention interventions, both in the context of controlled research and real-world sport environments. This study highlights key injuries and provides direction for future research into risk factors and prevention strategies. The aim was therefore to describe incidence, mechanism, nature and severity of injury in elite male hurling over a 5 year time span. Differences between subgroups of players, based on age and playing position were also explored.

METHODS

The men's senior grade county representative hurling competition commences in January, running through to September. The season includes preliminary cup and shield competitions, followed by the National Senior Hurling League and culminating in the All Ireland Senior Hurling Championship. This study focuses on teams enrolled to a National GAA Injury Database during the years 2007 to 2011. The data collection system opened from 1st January, each year, with teams prospectively followed until eliminated from the competition. Data collection ceased for the off-season, following the All Ireland Hurling Final, recommencing in January of the following year.

The only inclusion criterion for participation was that the team had a qualified professional i.e., medical practitioner or chartered physiotherapist present at every match and training session who could verify injury diagnosis and classification as well as game and training exposure hours. Injury data were entered weekly by the team personnel through a dedicated secure web portal, recording the information onto the National GAA Injury Database. The player participants were male players selected for their representative county team and the total sample recruited was determined by the number of teams who volunteered to participate.

Ethical Approval

Only de-identified player data were recorded. Players were given an opportunity to decline inclusion of their data in the team reports. Anonymity was maintained and data protection assured in accordance with ethical approval received from the University Research Ethics Committee (LS-E-11-91-OMalley-Blake).

Definitions

Consensus injury definitions for hurling were agreed with the GAA Medical, Scientific and Player Welfare Committee, following a review of international literature. These have been applied both to hurling and Gaelic football, its sister sport and have already been described in detail.[7,10] An information pack regarding injury definition and classification was distributed to each participating medical team and these were also embedded into the user interface in the online data collection tool.

Injury was defined as a time loss injury i.e. "any injury that prevents a player from taking a full part in all training and match 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". This definition was initially informed by that employed by Brooks et al.[11] and conforms with the time-loss injury classification proposed in consensus statements for soccer and rugby union.[12,13] Recurrence of injury was defined as 'a reinjury to a previously injured region'. This was sub-classified according to duration since original injury into early recurrent (within 2 months), late recurrent (2 to 12 months) and delayed recurrent (>12 months). Return to full fitness was deemed to be when the player was able to take part in full training activities and be available for match selection. Other agreed definitions included classification into acute injuries, overuse injuries or chronic injuries similar to the description used by Van Mechelen et al.[9] Severity of injury was classified as mild (lasting up to 1 week), moderate (up to 4 weeks) or severe (>4 weeks), with these times similarly relating to absence from training or match play.[9]

Procedures

The initial enrollment of players required that anthropometric and demographic details, position of play, involvement in other levels of competition, past injury and use of protective equipment were recorded. Age was defined in years, as of January 1st of that year. Players joining or leaving the squad were added or deactivated as required throughout the season. Thereafter the database was open for entry of new or updating of existing injury diagnosis at any time, but weekly injury data entry was required at minimum, as were details of training and match-play exposure hours. For new injuries, the team doctor or physiotherapist recorded; player code, position of play, ground conditions, date of injury, mechanism of injury, body region, main tissue injured, side of injury, whether recurrent or new and clinical diagnosis. Progression details for current injured players were also required weekly, including update of the status i.e. whether still injured or date of return to partial or full fitness.

Analysis

The data were analysed by calculating injury rates per 1000 hours, with 95% confidence intervals (CI), using the substitution method.[14,15] Percentages with 95% CI were derived, using Wilson's method.[15] Risk Ratios (RR) and 95% CI were used to compare injury rates. Chi square tests compared the observed to expected proportions of injured players according to playing position and age group. Computations were made using PASW Statistics, Release Version 18.0.0,[16] VRP Injury Analysis Software[17] and the Confidence Interval Analysis Package v 2.1.2.[18]

RESULTS

Twenty five male hurling teams were recruited; 4 for 2007, 5 for 2008, 7 for 2009, 5 for 2010 and 4 for 2011, so between 12.5% and 22% of competing teams per year were enrolled over this period. A total of 856 player seasons were followed and no player declined participation. The median squad size was 31 players (IQR = 28 to 33), with 15 of these taking to the field for each game. Mean age was 24.3 ±3.6 years (range 18 to 36; n=820). The duration of team enrolment ranged from 21 to 32 weeks (median=28) per season and so variable lengths of injury exposure were included in the incidence rate analysis.

Injury incidence

In total, 1030 injuries were recorded, giving a rate of 1.2 injuries per player registered. These injuries were sustained by 71% (608/1030; 95% CI 67.9 to 74.0) of the player cohort. Ninety two percent (948/1030) of injuries were attributed to single incidents occurring in the course of a match or training session, with the remaining 8% (82/1030) occurring insidiously, so these could not be identified as specific training or match injuries. Proportionately more injuries occurred in match play (56.9%) than training (35.1%) and the incidence rates per 1000 hours match play and training exposure are illustrated in table 1. The risk ratio for match play injury was 20.7 times that for training injury (96% CI 18.2 to 23.5).

Table 1. Injury incidence

	Exposure time (hours)	Number of injuries	% injuries	Injuries per 1000 hours	95% CI
Training injury	121119	362	35.1	2.99	2.68 to 3.30
Match injury	9490.5	586	56.9	61.75	56.75 to 66.75
Other injury		82	8.0		
Total injury		1030			
				Risk Ratio	**95% CI**
Injury risk ratio					
Match:Training				20.7	18.2 to 23.5

Where injuries were sustained on the field (n=952), the playing surface conditions were predominantly dry (80%, 95% CI 77.3 to 82.4). For injuries incurred during a competition match or structured training games, (n=702), the majority occurred in the third (32.3%, 95% CI 29.0 to 35.9) or fourth (33.2%, 95% CI 29.8 to 36.8) quarters of the session. In some cases of lower limb fracture and severe ligament disruption, the injured player did not return to the squad in that same season and so their time lost from play extended past the surveillance period. For those players whose injuries occurred and resolved in the same season, the median time loss for injury was 12 days, ranging from 2 to 127 days.

Playing position, age and injury

When observed injury classified by position of play was compared to expected injury, no statistically significant difference in injury proportions was noted between positions (χ^2 4.93, df=3, p=0.177), but it was interesting to see that the risk of injury was lower in goalkeepers

(0.62/player registered), compared to outfield players, where the ratio of injury to player enrolled ranged from 0.99 to 1.04 (table 2). Age distribution was also compared between the injured players and the total group and similarly no significant difference in proportion of injury by age group was found (χ^2 = 4.10, df=3, p=0.25). In this case, however, a stepwise increase in injury incidence proportion was seen with ascending age. The youngest age group (18-20 years) had a ratio of injury to players of 0.63, rising to 1.16 in the over 30 age group (table 2).

Table 2. Distribution of injured players by position and age range

	% injured players	% distribution all players	Ratio	P value
Defender	41.6	40	1.04	
Forward	41.0	40	1.02	
Midfield	13.2	13.3	0.99	χ^2=4.93, df=3
Goalkeeper	4.2	6.7	0.62	p=0.177
18-20	14.5	17.8	0.82	
21-24	35.7	36.5	0.98	
25-29	39.2	36.5	1.07	χ^2=4.10, df=3
30+	10.6	9.1	1.16	p=0.250

Main type of injury and regional distribution of injury

Injuries classified by location are presented in table 3, while table 4 illustrates the main type and tissue injured, with sub-classification for upper and lower limbs. Overall, the majority of injuries occurred in the lower limbs (68.3%), with an incidence rate of 5.4/1000 h (95% CI 5.2 to 6.0). Thigh injuries were the most common injury location (22.9%). The knee (11.3%) and ankle (9.3%) were the joints most frequently injured in the lower limb, while the foot, toes and hip had a lower incidence. Injuries to the pelvis/groin region constituted 10.3% of injuries overall. Upper limb injuries accounted for 18.6% of the total, with an incidence rate of 1.5/1000 h (95% CI 1.3 to 1.7). Collectively, injury to the distal part of the upper limb (wrist, hand, fingers and thumb) constituted 10.3% of all injuries (95% CI 8.6 to 12.3), while the shoulder and upper arm sustained 7.1% of injuries.

Soft tissue injuries were foremost overall, with muscle (36.9%), ligament (17.6%), tendon (7.6%), general joint trauma (7.6%), contusions (7.5%) and haematomas (3.8%) accounting for over 8 in 10 of all injuries. Close to 9% of injuries were bone fractures (table 4). When the type of tissue injury was compared between the upper and lower limbs a significantly (p<0.001) different distribution was evident (table 4). There were proportionately more fractures (36.1%) in the upper limb than in the lower limb (1.5%). In contrast, muscle strain constituted 45.8% of lower limb injury but only 5.2% of injuries to the upper limb. The trunk and spine region, including ribs, sustained 8.6% injuries, while just over 4% of injuries were to the head and neck region.

Mechanism and nature of injury

Contact with another player was responsible for 38.6% of all injuries (table 3). Sprinting accounted for almost one quarter of injuries with landing (13.7%) and turning (7.1%) the other commonly reported injury mechanisms (table 3). While the majority (80.8%) were new injuries, 17.4% were recurrent in nature. The proportions attributed to early, late and delayed recurrence can be seen in table 3. Similarly the majority were acute injuries (85.2%), with overuse mechanisms reported in 9.2%.

Table 3. Injury details

	Total (n=1030)		95% CI
LL injuries	**703 (68.3)**		**65.3 to 71.0**
Pelvis &Groin	106 (10.3)		8.6 to 12.3
Hip	24 (2.3)		1.6 to 3.4
Thigh	236 (22.9)		20.4 to 25.6
Knee	123 (11.9)		10.1 to 14.1
Shin	30 (2.9)		2.0 to 4.1
Calf	52 (5.0)		3.9 to 6.6
Ankle	96 (9.3)		7.7 to 11.3
Foot & Toes	36 (3.5)		2.5 to 4.8
UL injuries	**191 (18.6)**		**16.3 to 21.0**
Shoulder & Upper Arm	73 (7.1)		5.7 to 8.8
Forearm	11 (1.1)		0.6 to 1.9
Elbow	1 (0.1)		0.0 to 0.05
Wrist	15 (1.5)		0.9 to 2.4
Hand & Fingers	71 (6.9)		5.5 to 8.6
Thumb	20 (1.9)		1.3 to 3.0
Head and Neck	**42 (4.1)**		**3.0 to 5.5**
Trunk & Spine	**89 (8.6)**		**7.1 to 10.5**
Unspecified	**5 (0.4)**		**0.2 to 1.2**
Mechanism of Injury			
Contact with another player	398 (38.6)		35.7 to 41.7
Sprinting	252 (24.5)		21.7 to 27.2
Landing	141 (13.7)		11.7 to 15.9
Turning	73 (7.1)		5.7 to 8.8
Kicking	3 (0.3)		0.1 to 0.9
Warm up	9 (0.9)		0.5 to 1.7
Other	143 (13.9)		11.9 to 16.1
Unspecified	11 (1.1)		0.6 to 1.9
Recurrent/New Injury			
New injury	832 (80.8)		77.9 to 82.7
Recurrent injury	180 (17.4)		15.3 to 19.9
Early recurrent (<2 months)		68 (8.2)*	6.5 to 10.3*
Late recurrent (2 to 12 months)		49 (5.9)*	4.5 to 7.8*
Delayed recurrent (> 12 months)		33 (5.3)*	4.0 to 7.1*
Unspecified	18 (1.8)		1.1 to 2.7
Injury type			
Acute	880 (85.4)		83.2 to 87.5
Chronic	41 (4.0)		2.9 to 5.4
Overuse	95 (9.2)		7.6 to 11.1
Unspecified	14 (1.4)		0.8 to 2.3

* Recurrent injury not sub-classified in 2007. Percentage and CI calculated from total injury 2008-11 (n=826)

Table 4. Main type of injury

	Total (n=1030)	95% CI	Upper Limb (n=191)	Lower Limb (n=703)	p value
Muscle strain	380 (36.9)	34.0 to 39.9	10 (5.2)	334 (47.5)	
Ligament sprain	181 (17.6)	15.4 to 20.0	46 (24.1)	120 (17.1)	
Bone fracture	86 (8.3)	6.8 to 10.2	69 (36.1)	11 (1.6)	
Tendon	78 (7.6)	6.1 to 9.4	5 (2.6)	71 (10.1)	
Joint general	78 (7.6)	6.1 to 9.4	18 (9.4)	37 (5.3)	
Bone contusion*	77 (7.5)	6.0 to 9.2	17 (8.9)	55 (7.8)	
Haematoma	39 (3.8)	2.8 to 5.1	8 (4.2)	27 (3.8)	
Skin	30 (2.9)	2.0 to 4.1	13 (6.8)	8 (1.1)	
Meniscus	23 (2.2)	1.5 to 3.3	--	23 (3.3)	χ^2=315.4, df=9
Other / Unspecified	58 (5.7)	4.3 to 7.1	5 (2.6)	17 (2.4)	p<0.0001

*periosteal and osseous trauma, no fracture

DISCUSSION

The results presented here provide for the first time a comprehensive injury profile of elite hurlers, through prospective surveillance over 5 consecutive seasons. The key findings are that the incidence rate of injury for match play is 61.75/1000 hours, which is almost 21 times that of training (2.99/ 1000 hours), mirroring previous research over one season.[7] This excess risk of injury from match play is commonly seen in field sports, including Gaelic football (61.86/1000h match v 4.05/1000h training)[10], and soccer (26.6/1000h match v 4.0/1000h training) [19], reflecting the intensity of competition. However, it is notable that hurling demonstrates the highest relative risk of injury for matches versus training, amongst these sports.

The current data show that aggregated hurling injury rates are lower than those recorded in the single year snapshot taken in 2007, (102.5/1000 h (84.4 to 123.2) for matches and 5.3 (4.2 to 6.5) for training; RR=19.5 (14.8 to 25.6),[7] suggesting that incidence standardised for hours exposure has declined in subsequent years. Similarly, the incidence proportion of players is lower in the current pooled data than recorded in a single season (71% v 82%).[7] Multi-year surveillance is thus recommended to account for such variability, providing more precise population estimates with tighter confidence intervals.

An injury rate of 1.2 per player registered was recorded and it can be extrapolated that for the average squad of 31 players, competing for the average duration of 28 weeks; 37 time loss injuries would occur. Of these 6 (17%) would be recurrent injuries; and each injury would on average necessitate 12 days absence from training or match play. These injuries would be sustained by 22 players, while 9 would escape uninjured. Outfield players are at higher risk of injury than the goalkeeper, but no notable position related differences were seen. Injury risk increases with age, a factor noted in other sports.[20,21] This may due to greater susceptibility to injury with ageing, while the increased likelihood of an older player having prior injury due to increased sport exposure may be a confounding factor.

The development of consensus statements for injury definition, methods for expressing risk and assurance of professional diagnosis of the injury sustained[12,13], allows direct comparison of time loss injury incidence between sporting codes, which formerly would not have been possible due to methodological heterogeneity. We previously contrasted one year injury data in hurling with that available for football field sports,[7] finding that injury in hurling match play was close to that of rugby union. The findings reported here however clearly place the full-body contact sports of rugby sevens and rugby union higher in the overall match play injury risk hierarchy (106 and 91 injuries per 1000 h respectively),[11,22] with soccer match play incidence lower than hurling, as reported in the longstanding UEFA study (26.6-27.5 injuries per 1000 h),[19, 23]. It is difficult to make direct comparison with rugby league,[24] Australian Football League,[25] and American Football League[26] due to different injury definitions and reporting methods, but Gaelic football, the sister sport to hurling has a match play incidence rate (61.86/1000 h) directly equivalent to that of hurling.[10]

The most closely related field sports to hurling are shinty, another Gaelic stick handling game played in Scotland, lacrosse and field hockey. Research in shinty is limited to reports of injuries presenting at the emergency department[27] and there is a modest body of published descriptive epidemology in lacrosse and field hockey, with a focus on head, eye and hand injuries.[28-30] In men's intercollegiate lacrosse, a total incidence of 12.58 match injuries per 1000 athlete exposures (A-E) was reported,[28] but no comparable data for male field hockey is available. The nature and demands of bandy and ice hockey differ considerably from hurling, however it is interesting to make comparisons between these stick-handling sports. Timpka et al.[31] reported 7.3 injuries/1000 player game hours in 16 elite male bandy teams over one season and one study from an elite Japanese team, where a time loss injury definition was used, reported an injury rate of 11.7 injuries per 1000 game hours over 3 seasons.[32]

Upper limb injury

When comparing regional injuries as proportions of overall injury sustained, more reliable contrasts between sports can be made, although it must be acknowledged that more minor injuries, which did not require absence from training or games are not counted here due to the time-loss injury definition used. Thus it is not surprising that time-loss incidence rate here (1.5/1000 h), is markedly lower than the 19 injuries/1000 game hours recorded in a field hockey tournament where contusions were the most common injury.[33]

Almost 19% (95% CI 16.3 to 21.0) of all injuries in hurling were to the upper limb, the majority of which were fractures or sprains. The proportion of upper limb injury is comparable to NCAA men's lacrosse,[28] where the upper extremity accounted for 26.2% of game injuries and 16.9% of practice injuries, so it would appear that the frequency of upper extremity injury is similar in these sporting codes. Bowers et al.[29] compared hand injury in intercollegiate women's field hockey, women's lacrosse, men's ice hockey and men's lacrosse, finding significantly higher injury incidence in the ungloved hockey players compared to gloved athletes, a finding also reported by Mukherjee in field hockey.[33] Like field hockey, most hurling players play ungloved, so they too are at particular risk of contusion and laceration as well as carpal, metacarpal and phalangeal fracture as previously reported.[3,4] With all stick contact sports, the hand is susceptible to trauma due to direct blows from the opponent's stick or ball, but repetitive gripping, combined with forces transmitted to the hand and wrist may also contribute to injury. The use of an adhesive padded grip on the hurley stick itself is common, with the objective of enhanced grip, protection of the palm from friction and provision of some shock absorbency. Hurling gloves designed with dorsal padding and either low profile or absent palmar cover are also available to protect the player, without impeding grip, but unlike lacrosse and ice hockey, these are not prescribed as mandatory protective equipment. Hurling players can often continue to compete despite minor to moderate hand injury and so the extent and consequences of hand trauma may be under recognised. Further evaluation of these injuries is warranted and only longer-term follow up can identify the functional sequelae.

Lower limb injury

As previously reported in hurling,[6,7] lower limb injuries were dominant, with over two thirds of injuries being to the lower extremity in this cohort. It is also interesting to note that over 45% of injuries were attributed to non-contact mechanisms of sprinting, landing and turning. The thigh (22.9%) was the most common site and muscle (47.5%) the most common tissue injured in the lower limb. The proportion of lower limb injury may therefore be greater in hurling (68.3%) by comparison with approximately 48% of game and 59% of practice injuries recorded to the lower limb in men's collegiate lacrosse (Dick et al. 2007).[28] Dick et al.[28] reported that ankle ligament sprains ranged between 11.3% game and 16.4% practice injuries in men's lacrosse, contrasting with 9% (95% CI 7.7 to 11.3%) injuries overall to the ankle for hurling in the current study and 9% in an earlier report.[6] In hurling, the knee joint sustained just under 12% of injuries (95% CI 10.1 to 14.1%), while for male ice hockey, it has been reported that 10% (284/2828) of all injuries involved the knee ligaments[34] and that the knee was the most common game related (13.5%) lower extremity injury.[35] The data suggest that knee and ankle injuries do not vary widely between these sports.

Head, neck and trunk injury

Injury to the trunk, thoracic or lumbar spine represented 8.6% injury in hurling with most of these being soft tissue injuries and just over 4% of injuries were to the head and neck. When comparing to NCAA statistics, it was not unexpected that the proportion of head injury would be lower in hurling than in ice hockey (9% game, 5.3% practice),[34] given the chance of contact with another player, ice or boards in the ice rink. It was however surprising to see that hurling which allows overhead blocking and fielding of the ball, has a lower head injury incidence proportion than ladies field hockey (13% game injury, 3.4% practice injury),[36] while lacrosse also had a higher proportion (8.6% game injury, 3.6% practice injury) of head injury than our hurling cohort.[28] Further data collection over additional seasons is planned to allow systematic evaluation of subtypes of head injury and trends over time. However it is of note that no ocular injury was recorded in this elite cohort since the introduction of mandatory helmets with faceguards in 2010.

One limitation with this study is that the results here pertain to elite teams, so the generalisation of these findings to other levels of participation should be done with caution. Due to the voluntary nature of the injury reporting system, there was limited ability to accurately follow up the more severe injuries that were ongoing at the end of the season, since not all teams re-registered for subsequent seasons. Tracking of individual players rather than teams would have facilitated complete follow up, but due to the de-identification of players as part of the approved ethical procedures, this was not possible in this timeframe. For more complete data collection and better response rates, greater engagement with the medical teams is a priority and a mandatory injury recording system could be considered.

CONCLUSIONS

This study, while reporting on an indigenous game provides novel and relevant findings for the wider sports medicine community, since hurling is represented in sporting populations outside of the country of origin. The data presented here are the results of a commitment by the GAA, an amateur sporting organisation to adopt a strategic and theory-based approach to the problem of player injury starting with measurement of incidence. This report identifies the extent and nature of injury in hurling through a long-term prospective design, providing reliable information on the incidence and type of injuries sustained. We can contrast these with sport internationally and learn from injury prevention strategies employed in other codes. Ongoing injury surveillance, as described here, provides a platform to identify predictive factors and vulnerable subgroups of players, along with capacity to monitor changing trends in injury and to evaluate the effects of injury-prevention interventions.

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REFERENCES

1. Gaelic Athletic Association. Overseas Units. GAA, Dublin 2014. http://www.gaa.ie/content/documents/publications/overseas/Overseas_Booklet_100110233815.pdf
2. Gaelic Athletic Association. GAA Official Guide Part 2. Playing Rules of Football and Hurling. , Dublin 2012. Available at http://www.gaa.ie/content/documents/publications/official_guides/Official_Guide_2012_Part2.pdf
3. Flynn TH, Fennessy K, Horgan N et al. Ocular injury in hurling. *Br J Sports Med.* 2005;39(8):493-6; discussion 496. PMID: 16046328
4. Falvey E, McCrory P, Crowley B et al. Risk factors for hand injury in hurling: a cross-sectional study. *BMJ Open.* 2013;28;3(5). pii: e002634. doi: 10.1136/bmjopen-2013-002634. PMID:23793666
5. Kiely PD, Ashraff M, O'Grady P, Dawson MJ, O'Beirne JG. Hurling-related hand injuries. *Injury*. 2003;34(8):561-3. PMID: 12892715
6. Watson AW. Sports injuries in the game of hurling. A one-year prospective study. Am J Sports Med. 1996;24(3):323-8. PMID: 8734883.
7. Murphy JC, Gissane C, Blake C. Injury in elite county-level hurling: a prospective study. *Br J Sports Med*. 2012;46(2):138-42. doi:10.1136/bjsm.2010.072132.PMID: 20961917
8. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport.* 2006; 9 (1-2): 3-10 PMID: 19201766
9. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. Sports Med. 1992;14(2):82-99. PMID: 1509229
10. Murphy JC, O'Malley E, Gissane G et al. Incidence of Injury in Gaelic Football. A 4 year prospective study. *Am J Sports Med* 2012; 40(9): 2113-20 DOI: 10.1177/0363546512455315
11. Brooks JH, Fuller CW, Kemp SP et al. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *Br J Sports Med.* 2005;39(10):757-66. PMID: 16183774

12. Fuller CW, Ekstrand J, Junge A et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40(3):193-201. PMID: 16505073
13. Fuller CW, Molloy MG, Bagate C et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *Br J Sports Med.* 2007;41(5):328-31. PMID: 17452684
14. Daly L. Confidence limits made easy: Interval estimation using a substitution method. *Am J Epidem* 1998;147(8):783-790. PMID: 9554420
15. Campbell MJ, Daly LE, Machin D. Special topics. In *Statistics with Confidence 2nd ed.* Eds Altman DG, Machin D, Bryant TN, Gardiner MJ. BMJ Books, 2000 pp153-167
16. PASW Statistics version 18.0 IBM SPSS, Released August 2009. Chicago, IL, USA. http://www-01.ibm.com/software/analytics/spss/
17. VRP Injury Software. University of North Carolina Injury Prevention Research Centre), http://www.iprc.unc.edu/sportsinjurystatistics.shtml), accessed 10 July 2012
18. Bryant T. Confidence Interval Analysis Package version 2.1.2. 2000–2004. Southampton University of Southampton, 2000.
19. Hägglund M, Waldén M, Magnusson H et al. Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA Champions League injury study. Br J Sports Med. 2013;47(12):738-42. PMID: 23645832.
20. Arnason A, Sigurdsson SB, Gudmundsson A et al. Risk factors for injuries in football. *Am J Sports Med.* 2004;32(1 Suppl):5S-16S. PMID: 14754854.
21. Gabbe BJ, Bennell KL, Finch CF. Why are older Australian football players at greater risk of hamstring injury? *J Sci Med Sport.* 2006;9(4):327-33. PMID: 16678486.
22. Fuller CW, Taylor A, Molloy MG. Epidemiological study of injuries in international Rugby Sevens. Clin J Sport Med. 2010;20(3):179-84. PMID: 20445357.
23. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football: the UEFA injury study. Br J Sports Med. 2011;45(7):553-8. PMID:19553225
24. King DA, Gissane C. Injuries in amateur rugby league matches in New Zealand: a comparison between a division 1 and a division 2 premier grade team. *Clin J Sport Med.* 2009;19:277–81. PMID: 19638820

25. Orchard J, Seward H, Orchard J. *21st Annual Australian Football League Injury Report, 2012*. Released 6th March 2013 http://www.afl.com.au/staticfile/AFL%20Tenant/AFL/Files/AFLInjuryReportFor2012.pdf

26. Dick R, Ferrara MS, Agel J et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):221-33. PMID: 17710170

27. McLean JG. A survey of shinty injuries in the highlands during 1987–88. *Br J Sports Med* 1989;23:179–82. PMID: 2620234

28. Dick R, Romani WA, Agel J et al. Descriptive epidemiology of collegiate men's lacrosse injuries: national collegiate athletic association injury surveillance system, 1988–1989 through 2003–2004. *J Athl Train* 2007;42(2):255–61. PMID: 17710174

29. Bowers AL, Baldwin KD, Sennett BJ. Athletic hand injuries in intercollegiate field hockey players. *Med Sci Sports Exerc.* 2008 Dec;40(12):2022-6. PMID: 18981949.

30. Murtaugh K. Field hockey injuries. *Curr Sports Med Rep.* 2009;8(5):267-72. PMID: 19741355.

31. Timpka T, Risto O, Borg K et al. Injury incidence in a men's elite bandy league: an epidemiological study of a full regular season. *Scand J Med Sci Sports.* 2007 Dec;17(6):636-40. PMID: 17331084

32. Kuzuhara K, Shimamoto H, Mase Y. Ice hockey injuries in a Japanese elite team: a 3-year prospective study. *J Athl Train* 2009;44:208–14. PMID: 19295967

33. Mukherjee S. Traumatic upper limb injuries during the Men's Field Hockey Junior World Cup 2009. Res Sports Med. 2013;21(4):318-29. doi: 10.1080/15438627.2013.825797. PMID: 24067118

34. Agel J, Harvey EJ. A 7 year review of men's and women's ice hockey injuries in the NCAA. *Can J Surg.* 2010;53(5):319-23. PMID:20858376

35. Agel J, Dompier TP, Dick R et al. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train. 2007 Apr-Jun;42(2):241-48. PMID: 17710172

36. Dick R, Hootman JM, Agel J et al. Descriptive epidemiology of collegiate women's field hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-89 through 2002-2003. J Athl Train. 2007;42(2):211-20. PMID 17710169

Figure 1. Hurley, slíotar and helmet
90x120mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 – 4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12, 14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.