Physiotherapy Practice and Research 39 (2018) 99–105
DOI:10.3233/PPR-180112
IOS Press

Effects of the GAA15 in reducing lower extremity injury rates in adolescent males participating in hurling

Sean T. Kelly* and Clare A. Lodge
Department of Science and Health, Physiology Laboratory, Institute of Technology Carlow, Carlow, Ireland

Abstract.
PURPOSE: The aim of this analytical observation cohort study was to establish the effectiveness of the GAA15 (Gaelic Athletic Association 15) in reducing lower extremity injury rates (IR) in adolescent males playing hurling at post primary school level during one season.
METHODS: A sample of 516 male subjects (mean age 15.9 years ± SD 1.9), were recruited from fourteen post primary schools. Seven schools participated in the intervention group with equal group numbers in the control group. The intervention group implemented an injury prevention programme namely the GAA15 before training and matches. The control group adopted their normal warm-up behaviour prior to matches and training.
RESULTS: Control group participants sustained lower extremity training IRs of 15.83/1000 hrs (95% CI 9.4–22.3) compared to 8.78/1000 hrs (95% CI 5.2–12.4) in the intervention group ($p = 0.063$). Match lower extremity IRs of 36.32/1000 hrs (95% CI 21.1–51.5) were reported for the control group, with 25.62/1000 hrs (95% CI 16.9–34.4) reported for the intervention group participants ($p = 0.230$). Hurling lower extremity IRs were reduced by between 30% to 45% in the intervention group when compared to the respective control groups.
CONCLUSIONS: Following this investigation, it can be concluded that the implementation of the GAA15 is effective in reducing lower extremity injury rates in adolescent males participating in hurling when compared to a matched control group.

Keywords: Injury prevention programme, warm-up

1. Introduction

The game of hurling, which is one of Ireland's most popular team sports, is played by more than 300,000 registered players from over 2,000 affiliated GAA clubs throughout the 32 counties of Ireland [13, 14]. Over 200,000 youths aged between 8 and 18 years were members of the GAA in 2014 and these included pupils from 931 post-primary schools throughout Ireland [13, 14]. Hurling is similar to sports such as field hockey, lacrosse and shinty where players use hand held instruments to strike a ball. It is a game, which involves high intensity multidirectional pivoting movements, acceleration, deceleration, jumping and landing and upper body physical contact. Nationally, adolescent participation in organised sport has never been more popular, however, this increased level of activity raises concern over the risk and severity of injuries [19]. The majority of injuries adolescents receive during sport are not severe enough to necessitate hospitalisation, however, they may require medical treatment, resulting in rehabilitation costs and a potential delayed return to future sports participation [1]. Injuries in adolescent hurling are common with a third of adolescent players likely to sustain an injury during a playing season and over a quarter of these sustaining a subsequent injury during the same period [23]. Health consequences are not the only concern, significant financial implications are evident with over €8 million per year in insurance payouts previously recorded during the 7-year period

*Corresponding author: Sean T. Kelly, Physiology Laboratory, Department of Science and Health, Institute of Technology Carlow, Carlow, Ireland. E-mail: sean.kelly@itcarlow.ie.

from 2007 to 2014 [28]. It is speculated that by reducing injury incidences in Gaelic games a reduction in injury-claim expenses will follow.

School senior hurling (under 18.5 years), is split into two competitions, the league, which runs during a two-month period (October – November) and the championship, which starts in January and finishes with the All-Ireland final in March. Teams potentially have five games during the league (minimum of 3 games) and seven during the championship depending on how successful they are. School juvenile hurling, (under 14.5 years), is also structured on a league and championship competition framework with teams having a minimum of six games (February – April) and a maximum of ten games if they reach their respective finals. However, this match schedule does not consider other matches they may play with their schools, clubs or talent academies throughout the year. It is possible that some players may also be involved with multiple teams across different age groups, highlighting the fact that this cohort of hurling adolescents are potentially are at a greater risk of sustaining injury as they are playing with multiple teams in a relatively short time frame.

Neuromuscular injury prevention programs (IPPs) have become increasingly popular over the last number of years [1, 2, 8, 9, 15, 16]. Evidence from a variety of sports, including rugby, soccer and basketball suggests that these IPP programs consisting of mobility, flexibility, balance, plyometrics and functional strength can be effective in decreasing injury risk, if they are delivered correctly, and completed regularly [10, 16, 25]. Two IPPs are the FIFA11 and the GAA15, both of which were designed and developed to address the growing injury problem in their respective sports of soccer and Gaelic games. The FIFA11 was created in 2006, in conjunction with the Santa Monica Medicine Foundation, and the Oslo Sports Trauma and Research Centre as a sport specific warm-up to prevent injuries in amateur soccer players [2]. Similar to the FIFA11, the GAA's Medical, Scientific and Welfare Committee developed the GAA15 injury prevention program in 2011 using best practice from international research groups [1, 7, 8].

Even though the GAA15 has been in existence since 2011, there is a lack of evidence and questions remain as to its effectiveness amongst adolescent GAA teams. It is reported that this group are at risk from growth related injuries due to their young skeletally immature frame and potential overload due to the intense competition structure from school, club and talent academy participation [5]. Previous research is compelling and underlines the necessity to reduce the incidence of injury in this population group [5, 7, 28].

The purpose of this research was to evaluate the effects of the GAA15 on this adolescent cohort participating in post primary school hurling. It was hypothesized that the implementation of the GAA15 would reduce the incidence of injury in adolescent males participating in hurling compared to an age gender matched control group.

2. Methods

2.1. Experimental approach to the problem

This analytical observation cohort study utilized a nonrandomized convenience sample to establish the effectiveness of the GAA15 in reducing injuries in adolescent males playing hurling at post primary school level during one season. Comparisons were made to a matched control group whose subjects participated in normal pre-training and pre-match warm-up methods. Schools were selected and assigned to either the experimental or control groups based on their geographical convenience to the centre of research, the Institute of Technology Carlow, Ireland.

2.2. Subjects

A total of 516 participants (mean age 15.9 years $\pm$ *SD* 1.9) were recruited from fourteen post primary schools from two Irish provinces Leinster and Munster (Intervention Group $n = 305$; Control Group $n = 211$). Data collection took place during the 2015/2016 hurling season, between September 2015 and April 2016. Parents/guardians, coaches and participants were informed, through information workshops and written handouts, on the details, purpose and benefits of the research investigation and to the prerequisites if they agreed to participate. Ethical approval was obtained from the Institute of Technology Carlow, Ireland Research Ethics Committee. Parental and participant informed consent was obtained from participants prior to research commencement.

2.3. Procedures

School hurling coaches and team trainers, were briefed and educated on the purpose of the study

with supporting data through a workshop. The intervention group coaches and trainers were instructed on the components of the GAA15 intervention programme and how to integrate it into their pre-match routine and before every hurling training session. Supplementary DVDs, of the selected GAA15 neuromuscular warm-up programme, along with a printed copy of the programme structure, layout and routine was provided as supporting material. Compliance and adherence was key to this study and this was emphasized to the coaches. In order to facilitate this, coaches from the intervention schools were contacted via telephone on a weekly basis and visited biweekly by the primary investigator. The teams in the control group utilised their normal warm-up routine before hurling training and matches during the investigation period.

The implemented GAA15 had three different sections involving six types of activity, which were performed at the beginning of match and training sessions and took between 15–20 minutes to complete (see Table 1). The primary activities included dynamic flexibility, proprioception, speed, agility, jumping, strengthening exercises and sport specific movements.

Epidemiological data was collected from each of the players via a self-reported mobile phone web application (Smartabase Athlete Data Management, Fusion Sport, Summer Park, QLD, Australia). Participants entered information on a daily basis, including the number of hurling training sessions and matches along with the playing activity duration (mins). Short messaging service (SMS) text reminder messages were sent to each participant through the web application three times per week (every second day). Participants reported their injury details following hurling training or match activity during the investigation period. From this information injury rates (IR) per 1000 hours of activity, with respective 95% confidence intervals (CI) were determined. All players involved in the research were provided with a definition for injury through a workshop seminar to enable consistency of tracking injuries across all participating schools. An injury was defined as "any injury sustained during hurling training or competition resulting in time lost from play or athlete reported restricted performance" [4, 6, 11, 21–23]. All data collected via the application was then translated into training and match IRs. IR was defined as the number of new injuries divided by the total exposure time (hours) of a participant activity during the research period, using the subsequent calculation [18].

$$\begin{aligned}&\textit{Injury Rate } (IR) = \text{Number of new injuries}\\&\div\text{Athlete exposure time (hours)} \times 1000\\&\textit{95\% Confidence Interval } (CI)\\&= \text{IR} \pm 1.96 \times \text{SE(IR)}\\&\textit{Standard Error } (SE) = \sqrt{\text{Number}} \text{ of Injuries}\\&\div\text{Total hours playing sport}\end{aligned}$$

The average risk of injury (IP) was quantified by dividing the number of participants who sustained one injury during the research period by the number of participants at risk during the same period [23].

$$\begin{aligned}&\textit{Incidence Proportion } (IP)\\&= \frac{\text{Number of injured participants during research period}*}{\text{Number of participants at risk during research period}}\\&\textit{95\% Confidence Interval } (CI) = \text{IR} \pm 1.96\\&\times\text{SE(IP)}\\&\textit{Standard Error } (SE) = \sqrt{\text{IP}} \times (1 - \text{IP}) \div \text{N}^{**}\end{aligned}$$

*Participants who sustain at least one injury.

**Total number of participants at risk during research period (one season).

Rate ratios were calculated to determine how much higher a group's injury incidence rate was compared to another [23].

$$\textit{Injury Rate Ratio } (IRR) = \frac{\textit{Intervention Group IR}}{\textit{Control Group IR}}$$

Odds ratios (ORs) were calculated to estimate group sizes. The OR was defined as the number of participants who sustained an injury during the research period divided by the number of participants who remained injury free.

$$\begin{aligned}&\textit{Odds Ratio } (OR)\\&= \frac{\textit{Number of injured participants during research period}}{\textit{Number of participants who remained injury free}}\end{aligned}$$

2.4. Statistical analyses

Statistical analysis of the data was performed using IBM SPSS (Statistical Package for Social Sciences, version 22.0). Baseline characteristics, measured as continuous variables, were displayed as mean plus standard deviation (SD) and categorical variables such as number of injuries were expressed as percentages [27]. A Shapiro Wilk test was used on the complete data set to investigate for normality of data. Injury data was examined by calculating percentages and injury rates per 1000 hrs with 95% confidence

Table 1
The GAA15 – Structure of the injury prevention warm-up programme

Goals	Exercise description	Duration	Total time
	SECTION 1 – Dynamic Flexibility		
Warm-Up, Raise Body Temperature	Slow runs forward, complete 20 mts × 2 (twice)	60 sec	
	Slow runs backwards, 20 mts × 2		
	Lateral side shuffle, right and left, 20 mts × 2	60 sec	
	Skip forward, 20 mts × 1		
	Jog with high knees, 20 mts × 1	40 sec	
	Jog with heel flicks, 20 mts × 1		
	Dynamic calf stretch, 20 sec × 1	20 sec	
	Section 1	3 mins	3 mins
	SECTION 2 – Agility and Strength		
Proprioception, Change of Direction (COD), Jumping, Landing and Strength.	Forward runs with COD, left and right, 20 mts × 2	30 sec	
	Single leg balance with hip internal movement into a forward lunge, complete × 8 reps (arms raised)	150 sec	
	Single leg balance with hip external movement into a reverse lunge, × 8 (arms raised)		
	Body weight squats, complete × 8 reps	50 sec	
	Inchworm with press-up and trunk rotation left and right, complete × 6 reps	60 sec	
	Single Leg T-Plane Balance, complete × 6ea. leg	60 sec	
	Counter movement jump, double leg, complete × 8	130 sec	
	Forward diagonal bounds to single leg land and stick × 8		
	Section 2	8 mins	
	Total		11 mins
	SECTION 3 – Sports Specific Movement		
Sport Specific Speed	80% (max pace) Speed run, complete 20 mts × 2 slow jog back × 2	80 sec	
	90% (max pace) Speed run, 20 mts × 2 slow jog back × 2	80 sec	
	100% (max pace) Speed run, 20 mts × 2 slow jog back × 2	80 sec	
	Section 3	4 mins	
	Total		15 mins

Mts = metres, sec = seconds, mins = minutes, reps = repetitions, ea. = each, COD = change of direction.

intervals (CIs). Incidence proportions (IPs) and risk ratios (RRs) were used to compare injuries and were calculated using VRP Injury Statistics Software [12].

3. Results

Table 2 represents the hurling injuries that were recorded during the investigation period, giving a total injury incidence (IR) rate of 20.63 (95% CI 17.3–23.9) injuries per 1000 hours of participation. The total hurling training IR was 16.21/1000 h (95% CI 12.3–20.1), which was less than half the IR for competitive matches of 39.61/1000 h, (95% CI 30.6–48.6) with an IRR of 0.41 (95% CI 0.30–0.57).

The total IR for the control group was 20.88 (95% CI 14.6–27.1) injuries per 1000 hours of participation with an OR of 0.87 compared to 13.57 (95% CI 9.9–17.2) injuries per 1000hours in the intervention group with an OR of 0.68 and IRR 0.65 (CI 0.45–0.93, $p = 0.0477$). This IR was further broken down to reveal a control group training rate of 15.83/1000 h (95% CI 9.4–22.3) and match rate of 36.32/1000 h (95% CI 21.1–51.5), IRR 0.55 (95% CI 0.31–0.99), $p = 0.0629$ compared to the intervention training IR of 8.78/1000 h (95% CI 5.2–12.4) and match IR of 25.62/1000 h (95% CI 16.9–34.4) an IRR of 0.70 (95% CI 0.41–1.20), $p = 0.2301$.

Injuries to the lower extremity were most common (66%) during the research period. Lower extremity IRs for all participants was 13.99/1000 h (95% CI 11.3–16.7) with match injury rates 29.04/1000 h (95% CI 21.4–36.7) OR 0.25 more than 2.5 times higher than training injuries which were 11.29/1000 h (95% CI 8.0–14.6) OR 0.15 with an IRR of 0.39 (95% CI 0.26–0.57).

Table 2
Hurling injury details

Injuries per 1000 hrs	IR	95% CI	IP	95% CI	Control IR	Control 95% CI	Control OR	Intervention IR	Intervention 95% CI	Intervention OR	IRR	95% CI	*p*-value
Total Injury Incidence Rate													
Total	20.63	17.3–23.9											
Training	16.21	12.3–20.1											
Match	39.61	30.6–48.6											
Lower Extremity Incidence Rate													
Total	13.99	11.3–16.7			20.88	14.6–27.1	0.87	13.57	9.9–17.2	0.68			0.0477*
Training	11.29	8.0–14.6	0.13	0.09–0.17	15.83	9.4–22.3		8.78	5.2–12.4		1.80	1.01–3.20	0.0629
Match	29.04	21.4–36.7	0.20	0.15–0.25	36.32	21.1–51.5		25.62	16.9–34.4		1.42	0.83–2.41	0.2301
Training : Match											0.39	0.26–0.57	

IR = Incidence Rate, CI = Confidence Interval, IP = Incidence Proportion, IRR = Incidence Rate Ratio, OR = Odds Ratio, * = Statistical Significance.

The concluding calculations in Table 2 represent the IRR, which measures the difference in IRs between 2 groups. Results from school training revealed a 45% reduction in the rate of lower extremity injuries in the intervention group compared to the control group. Similar results were established from competitive school hurling matches with a 30% reduction of lower extremity injury rates between the intervention and control groups.

The risk of injury during the research period revealed an IP of 0.13 (95% CI 0.09–0.17), a 12.7% risk of incurring a lower extremity injury in school training and an IP of 0.20 (95% CI 0.15–0.25), a 19.8% risk of incurring an injury in school hurling matches.

4. Discussion

The findings of this investigation support the utility of the GAA15 in adolescent hurlers, evidence suggests that this IPP can reduce lower extremity injuries in this cohort. It has previously been suggested that IPPs should be a fundamental part of any team's preparation for competition [26]. Evidence from previous research on the utility of the FIFA11 suggests that it is possible to achieve injury reductions of between 30 to 70% by using the programme two to three times per week before training and matches [26, 27, 30]. Similarly, other injury prevention programmes such as the Prevent injury, Enhance Performance (PEP) revealed up to 88% reduction in injuries, the Knäkontroll revealed a 64% reduction and the Preventing Australian Football Injuries with Exercise (PAFIX) a 22% reduction all of which are comparable to the current findings [9, 20, 32]. It is acknowledged that the current study reports a lower reduction of injury rates than three of the four studies mentioned above, with methodological differences, procedures, age profile of participants and medical staff used to diagnose injuries as some of the reasons for this disparity. This current investigation established positive results favoring the intervention group, with a 35% reduction in all lower extremity injuries when compared to the control group participants (IR 20.88 and 13.57/1000 hrs, respectively).

4.1. Incidence rate (IR)

The overall injury IR for the current study was 20.63 injuries per 1000 hours of activity (95% CI 17.3–23.9). This was further broken down to reveal a lower extremity IR of 13.99/1000 hrs (95% CI 11.3–16.7) with training injuries accounting for 11.29/1000 hrs (95% CI 8.0–14.6) and a match IR of 29.04/1000 hrs (95% CI 21.4–36.7). These results are consistent with other hurling studies showing an increase in injury incidence while participating in matches [3, 22, 23]. Other multidirectional field sports reported similar findings with soccer, lacrosse, and Australian rules football all recording higher rates of injury during matches when compared to training [7, 8, 17].

The reported total IR (20.63/1000 hrs) in the current study was higher than adolescent lacrosse (12.98/1000 per Athletic Exposures), which could be considered comparable to hurling with players using sticks to play a multidirectional physical contact game [17]. However, the lacrosse investigation had an athletic trainer reporting injuries and exposure details for each team, consisting of young children from the age of 9 up to 15 years of age, which may have contributed to the low rates of injury displayed. In addition, injury rates were calculated per

athlete exposure (defined as one player participating in one game or one training session) and not per hours of participation. When compared to adult hurling players (training IR 2.99/1000 hrs and match IR 61.75/1000 hrs), the results of this study established a training injury IR of 11.29/1000 hrs, which is nearly four times higher than those of the adults and a match injury IR of 29.04/1000 hrs, which was half the reported adult IRs [3]. The sizeable disparities in observed injury rates between these two studies could be due to the age of the adolescent participants in this study compared to adult players (over 18 years) in comparable studies [3, 22]. It has been suggested that adult players are physically more developed and play matches at a higher intensity at elite level, which could reflect the higher rates of injury during match play [22]. It is not clear why the reported training IRs in the current study are higher than comparable adult hurling studies. It could be speculated that elite adult players are more physically conditioned, have attained skeletal maturity compared to their adolescent counterparts and do not have the same competition structure requiring multiple team participation. These explanations could place the younger player at a greater risk of sustaining training injuries. Despite having similar injury patterns to adults, other factors such as skeletal, physiological, psychological and hormonal maturity along with fitness and skill levels need to be carefully considered when comparing injury rates between adults and adolescents [29].

The current research reported a 45% reduction in lower extremity training injury rates in the intervention group compared to the control group (control IR 15.83/1000 hrs, intervention IR 8.78/1000 hrs). These findings are consistent with other multidirectional field sports IRs such as soccer (control 15.04/1000 hrs; intervention 8.09/1000 hrs) and Australian rules football (control 14.7/1000 hrs; intervention 11.8/1000 hrs), reporting 46% and 20% reductions respectively [9, 30]. The reported injury reduction in school participants in the current study was shown to be greater than the results of a systematic review and meta-analysis of the FIFA11 programme which reported a 39% decrease in soccer injuries [31]. It is acknowledged that the % decrease in IRs in the current study is not statistically significant ($p = 0.0629$), but from a practical viewpoint, this reduction should encourage team coaches to consider using IPPs like the GAA15 to assist in the reduction of lower limb injuries. There was a 30% reduction in the rate of lower extremity match injuries in school adolescent male hurlers participating in the GAA15 IPP (control group 36.32/1000 hrs v's intervention group 25.62/1000 hrs).

Participants were 61% (IRR 0.39) more likely to incur a lower extremity injury while playing a match compared to training. Overall, match injuries were more prevalent than training injuries in this investigation, however, the results were noticeably less than one previous adolescent GAA study [24], with participants 4.85 times more likely to be injured playing a match compared to training. Results were even greater at senior (adult) level, with two former prospective studies [3, 22] showing participants 20.7 and 19.3 times more likely to obtain an injury while playing a match compared to training.

4.2. Limitations

Compliance of the intervention was not monitored due to the large number of participants and the varied geographical locations of the participating schools. In order to ensure optimal uptake, adoption and implementation it is recommended that a randomized control trial involving post primary school athletes with compliance monitoring be planned to confirm these findings and efficiency of the GAA15 in decreasing lower extremity injuries in the adolescent athlete.

A further limitation of the study was the timeframe and the interruption of participation due to the "knock-out" nature of the sport for this cohort. A longer investigation period would be recommended to improve IPP adherence and player monitoring.

The self-reporting nature of injury that was utilized in this study could be addressed by using research informed allied health professionals in the diagnosis of injury in future studies to medically verify and categorise injury.

Secondary to the widespread nature of the GAA calendar, for the different age groups, and the fact that players partake in more than one age group and or playing level, data collection and intervention compliance could be improved by focusing on one particular age group at a specific time of year (League or Championship). Furthermore, a randomised control trial with analysis of clustered data for one defined age group would provide much needed age-specific statistics and information for the GAA.

5. Conclusion

Performing research to practice behaviour is paramount in injury prevention research. The results

of this preliminary investigation demonstrate that positive results can be achieved from the implementation of a neuromuscular injury prevention warm-up, namely the GAA15, in reducing lower extremity injury rates by between 30% to 45% in adolescent males participating in hurling.

Conflict of interest

None to report.

References

[1] Abernethy L, Bleakley C. Strategies to prevent injury in adolescent sport: A systematic review. British Journal of Sports Medicine. 2007;41(10):627-38.

[2] Bizzini M, Dvorak J. FIFA 11+: An effective programme to prevent football injuries in various player groups worldwide—a narrative review. Br J Sports Med. 2015;49:577-9.

[3] Blake C, et al. Epidemiology of injuries in hurling: A prospective study 2007-2011. BMJ Open. 2014;4(6): e005059.

[4] Brooks JHM, et al. Epidemiology of injuries in English professional rugby union: Part 1 match injuries. British Journal of Sports Medicine. 2005;39(10):757-66.

[5] Caine D, Purcell L, Maffulli N. The child and adolescent athlete: A review of three potentially serious injuries. BMC Sports Science, Medicine and Rehabilitation. 2014;6(1):22.

[6] Clarsen B, Bahr R. Matching the choice of injury/illness definition to study setting, purpose and design: One size does not fit all! British Journal of Sports Medicine. 2014;48(7):510-2.

[7] Emery C, Meeuwisse W, Hartmann S. Evaluation of risk factors for injury in adolescent soccer. The American Journal of Sports Medicine. 2005;33:1882-91.

[8] Finch C, Lloyd D, Elliott B. The preventing australian football injuries with exercise (PAFIX) study: A group randomised controlled trial. Injury Prevention. 2009;15(3):e1-e1.

[9] Finch CF, et al. Preventing Australian football injuries with a targeted neuromuscular control exercise programme: Comparative injury rates from a training intervention delivered in a clustered randomised controlled trial. Injury Prevention. 2015;p.injuryprev-2015-041667.

[10] Fortington LV, et al. When "just doing it" is not enough: Assessing the fidelity of player performance of an injury prevention exercise program. Journal of Science and Medicine in Sport. 2014;18(3);272-7.

[11] Fuller CW. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. British Journal of Sports Medicine. 2006;40(3):193-201.

[12] Conor Gissane 2007, VRP Injury Statistics Software (Predicting the Risk of Injury).

[13] GAA. Chomhdháil Bhliantúil 2015 Annual Congress. End of Year Report. 2015.

[14] GAA. An Chomhdháil Bhliantúil 2016, Annual Congress End of Year Report. 2016.

[15] Grooms DR, et al. Soccer-specific warm-up and lower extremity injury rates in collegiate male soccer players. Journal of Athletic Training. 2013;48(6):782-789.

[16] Herman K, et al. The effectiveness of neuromuscular warm-up strategies, that require no additional equipment, for preventing lower limb injuries during sports participation: A systematic review. BMC Medicine. 2012;10(1):75.

[17] Kerr ZY, et al. The epidemiology of boys' youth lacrosse injuries in the 2015 season. Injury Epidemiology. 2016;3(1):3.

[18] Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. Journal of Athletic Training. 2006;41(2):207-15.

[19] Lunn P, Kelly E, Fitzpatrick N. Keeping Them in the Game: Taking Up and Dropping Out of Sport and Exercise in Ireland. 2013.

[20] Mandelbaum BR, et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. The American Journal of Sports Medicine. 2005;33(7):1003-10.

[21] Murphy JC, et al. Incidence of injury in gaelic football: A 4-year prospective study. The American Journal of Sports Medicine. 2012;40(9):2113-20.

[22] Murphy JC, Gissane C, Blake C. Injury in elite county-level hurling: A prospective study. Br J Sports Med. 2012;46(2):138-42.

[23] O' Connor S, et al. Epidemiology of injury in male adolescent Gaelic games. Journal of Science and Medicine in Sport. 2016;19(5):384-8.

[24] O' Connor S, et al. Epidemiology of injury in male adolescent Gaelic games. Journal of Science and Medicine in Sport / Sports Medicine Australia. 2015;2-6.

[25] O'Malley E, et al. The effects of the GAA 15 training program on neuromuscular outcomes in Gaelic football and hurling players; a randomized cluster trial. Journal of Strength and Conditioning Research. 2016.

[26] Owen A, et al. Effect of an injury prevention program on muscle injuries in elite professional soccer. Journal of Strength and Conditioning Research. 2013;27(12):3275-85.

[27] Owoeye OBA, et al. Efficacy of the FIFA 11+ warm-up programme in male youth football: A cluster randomised controlled trial. Journal of Sports Science and Medicine. 2014;13(2):321-8.

[28] Roe M, et al. Injury Scheme Claims in Gaelic Games: A Review of 2007–2014. 2016;51(4).

[29] Scase E, et al. The epidemiology of injury for an elite junior Australian Football cohort. Journal of Science and Medicine in Sport. 2012;15(3):207-12.

[30] Silvers-Granelli H, et al. Efficacy of the FIFA 11+ injury prevention program in the collegiate male soccer player. The American Journal of Sports Medicine. 2015;43(11): 2628-37.

[31] Thorborg K, et al. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: A systematic review and meta-analysis of the FIFA 11 and 11+ programmes. British Journal of Sports Medicine. 2017;p.bjsports-2016-097066.

[32] Waldén M, et al. Prevention of acute knee injuries in adolescent female football players: Cluster randomised controlled trial. BMJ (Clinical research ed.). 2012;344:e3042.