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Communicating the risk of injury in schoolboy rugby: using Poisson probability as an alternative presentation of the epidemiology

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ABSTRACT

Background The communication of injury risk in rugby and other sports is underdeveloped and parents, children and coaches need to be better informed about risk.

Method A Poisson distribution was used to transform population based incidence of injury into average probabilities of injury to individual players.

Results The incidence of injury in schoolboy rugby matches range from 7 to 129.8 injuries per 1000 player-hours; these rates translate to average probabilities of injury to a player of between 12% and 90% over a season.

Conclusion Incidence of injury and average probabilities of injury over a season should be published together in all future epidemiological studies on school rugby and other sports. More research is required on informing and communicating injury risks to parents, staff and children and how it affects monitoring, decision making and prevention strategies.

INTRODUCTION

Sport is a major cause of child and adolescent injury.[1] Rugby union, a high contact sport, has high rates of injury in adults and children alike.[2] A concern is whether parents, school children and coaches have sufficient understanding of risks of injury. Fuller identifies the communication of risk in sport as a critical but underdeveloped element of injury risk management.[3] The literature on risk communication endorses the use of probabilities as necessary for a comprehensive understanding of risk.[4 5] Research evidence suggests that the framing of statistical data influences public perception of risk.[3 5]

The epidemiology of schoolboy rugby injuries is most commonly reported as incidence of injury per player-exposure, a population measure which does not convey the average probability of injury to an individual player during a rugby season.

This paper demonstrates a new application of an existing methodology, namely the Poisson distribution, to transform epidemiological data on injury rates to probabilities of injury for players. This methodology could and should be applied to other sports and for monitoring of individual sports.

METHODS

The Poisson distribution predicts the probabilities of numbers of injuries resulting from a particular time exposure, either over time for a single player, or for players in a squad, conditional on the injury incidence.

The Poisson model is a standard model in risk analysis and is applicable where events of a particular class occur independently over time.[6] One of the first applications of the Poisson model was to injuries of soldiers within the Prussian cavalry.

The model requires the following variables and data: injury incidence, exposure- length of matches and number of matches played in a season.

The main input is the incidence of injury as number of injuries per player-hour.

Where studies do not provide precise information on length and number of games: the length of matches is taken to be 70 min, conforming to the U19 International Rugby Board (IRB) laws and regulations[7] and the number of competitive games played in a schoolboy season is assumed to be 15.[8–10]

The Poisson distribution model assumes that injuries occur with a known average rate and independently of the time since the last injury.

The probability of '*k*' number of injuries in total time '*t*' (hours) of play

$$P(k) = \frac{(\lambda t)^k e^{-\lambda t}}{k!}, \text{ for } k = 0,1,2, \dots \text{ where}$$

λ = injury incidence (eg, for 43.3 injuries per 1000 player-hours, λ = 0.0433. This figure is within the range reported from published studies and we will use it to provide some illustrative examples)

t = time-interval, hours (eg , for 15 matches, t = 15 × (70/60) = 17.5 h)

e = base of the natural logarithm (e = 2.71828…)

$k!$ = factorial of '*k*'

This formula gives the probabilities shown in table 1.

Table 1 shows that, subject to injury incidence of 43.3/1000 player-hours, the probability of a player completing 15 games without injury is 46.9%. The expected number of injuries (the different possible numbers weighted by their probabilities) equals the injury incidence times the length of exposure = λt, that is, can be represented in terms of our distribution as:

$1\times0.355 + 2\times0.135 + 3\times0.034 + 4\times0.001 + \dots = 0.0433\times17.5 = 0.758$.

Although the Poisson distribution is sometimes called "the law of rare events" it requires not that events be rare, but that the time to the next event is independent of the time since the last one. The process is 'memory-less' in the sense that the expected time to the next injury does not depend on how long it has been since the last one.

Assuming every player faces a similar risk of injury, the model can alternatively be used to predict the probability of injury for a squad of players. In this context the value of 't' in the formula becomes the total number of player-hours exposure (eg, one 70 min game is 17.5 h of total player-exposure for one squad) at the injury incidence 'λ', and 'k' is the total number of injuries occurring in the squad.

Table 1 Probabilities of injuries to a single player from an exposure to 17.5 h of play (ie, 15-completed games) and an injury incidence of 43.3 per 1000 player-hours

Number of injuries from 17.5 h playing exposure	Probability (injury incidence of 43.3/1000 player hours)
0	46.9%
1	35.5%
2	13.5%
3	3.4%
4	0.6%
5	0.1%

RESULTS

Application to previous studies

Table 2 shows population-based injury incidence of ten observational studies in schoolboy rugby and their transformation into probabilities.[8–17]

Table 3 shows injury incidences converted to probability (percentages and approximate frequencies).

DISCUSSION

The large variation in probability of injury across studies is due to different definitions of injury and the IRB has published guidelines for the future.[18]

The definition of injury risk is not defined in a standard way for rugby; Knowles et al defined injury risk as the "average probability of injury per athlete" and Fuller and Drawer defined 'risk' to athletes as "the probability or likelihood that a hazard will have an impact on these people", and this is consistent with other literature on medical risk[5 19 20] As with occupational injury, risk of sports injury increases with exposure.[21 22]

The UK Health and Safety Executive defines acceptable and unacceptable levels of occupational risk in terms of the

Table 2 Translation of injury incidences to probabilities of injury

Study	Injury definition	Population (schoolboys; ages)	Injury incidence	Average probability of injury to a player in a season
Nathan 1983 (South Africa)[11]	Injury prevents rugby participation for at least 1 week	<10 – <19	8.4 per 1000 player-hours	14%
Sparks 1985* (UK)[12]	Injury prevents rugby participation for at least 1 week	<14	27.4 per 1000 player-hours	38%
		<15	54.2 per 1000 player-hours	61%
		<16	29.4 per 1000 player-hours	40%
		1st–4th XV	43 per 1000 player-hours	53%
Davidson 1987 (Australia)[13]	Injuries that required attention at the school sport's clinic	<13	13.6 per 1000 player-hours	21%
		14–15	18.4 per 1000 player-hours	28%
		>16	25.6 per 1000 player-hours	36%
Roux 1987 (South Africa)[9]	Injury prevents rugby participation for at least one week	<14 – <19	7 per 1000 player-hours	12%
Durie 2000* (New Zealand)[8]	Injury causes player to leave field or complain at end of the match.	<13	19.6 per 1000 player-hours	29%
		<14	20.8 per 1000 player-hours	31%
		<15	25 per 1000 player-hours	35%
		<16	25.9 per 1000 player-hours	36%
		<17	25 per 1000 player-hours	35%
		1st – 5th XV Average	40.1 per 1000 player-hours	50%
Junge 2004 (New Zealand)[14]	Any physical complaint	14–18	129.8 per 1000 player-hours	90%
McIntosh 2005 (Australia)[15]	All match injuries	<13	41.4 per 1000 player-hours	52%
		<15	40.4 per 1000 player-hours	51%
		<18	52.6 per 1000 player-hours	60%
McIntosh 2008 (Australia)[16]	Injury required treatment or removal from pitch	<13	43.3 per 1000 player-hours	53%
		<15	56.3 per 1000 player-hours	63%
		<18	63 per 1000 player-hours	67%
Haseler 2010 (UK)[17]	Injury results in inability to take full part in future training or match play	<9	0 per 1000 player-hours	0%
		<10	6 per 1000 player-hours	9%
		<11	11 per 1000 player-hours	18%
		<12	23 per 1000 player-hours	33%
		<13	20 per 1000 player-hours	22%
		<16	28 per 1000 player-hours	39%
		<17	49 per 1000 player-hours	58%
Nicol 2010 (UK)[10]	Injury results in inability to take full part in future training or match play	11–18	10.8 per 1000 player-hours	17%

*In these studies, injury incidences were provided for levels of play within individual age-groups, that is, A-group, B-group etc. An average injury incidence was calculated for each age-group, to allow comparison between age-groups of different studies.

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Table 3 Conversion table for transforming injury exposure rates to probabilities

Injury incidence Injuries/1000- player hours	Probability of injury to average player in a 15-match season as percentage and approximate frequency
< 10 per 1000 player-hours	< 16% (< 1 in 6)
10 – 19 per 1000 player-hours	16 – 30% (1 in 6 to 1 in 3)
20 – 39 per 1000 player-hours	30 – 50% (1 in 3 to 1 in 2)
40 – 60 per 1000 player-hours	50 – 65% (1 in 2)
> 60 per 1000 player-hours	> 65% (> 1 in 2)

probability that a serious adverse event would occur in one year, and not in terms of injury incidence per worker-exposure.[23] The US National Safety Council used an 'Odds' table for their 2011 report of injury statistics in response to "frequent inquiries" from people asking for "odds" and "chances" of fatality as a result of particular situations.[24] Meanwhile, the Statistical Office of the European Communities (Eurostat) publishes information on accidents at work in terms of the number of accidents per 100 000 people.[25]

The safety of rugby union has been questioned by parents,[26] but without information on risks and liability neither parents nor children can give meaningful consent, this is a particular issue in schools where rugby is compulsory in the sport's curriculum.[27] We would suggest table 3 can be used to inform parents and children about the probabilities and risks of injury based on previous season's injuries.

Limitations

Exposure

Injury incidence describes statistical injury data within the context of a hypothetical exposure period (usually 1000 player-hours), while the probabilities described already incorporate this exposure. The input of this exposure information is based on the study's observation period, and the probabilities are based upon this precise time exposure. If the playing time is shared among a squad of 20 players including substitutes instead of a team of 15, the probability of any given player being injured is reduced as a function of their actual playing time.

The probability analysis using the Poisson distribution model requires injury data to be reported as an injury incidence. The methodology cannot be used to translate injuries per 'athlete-exposures' into average injury probabilities because the model requires time-exposure, that is, player-hours.

Heterogeneity of players

Characteristics of individuals differ between players, with internal and external factors known to affect the risk of injury to an athlete.[28] Some players may therefore have lower than average injury rates, while others have higher than average ones.

CONCLUSIONS

Injury incidence can be transformed into average probability of injury using a simple Poisson distribution model.

Probabilities are the most familiar method of communicating risk to the public, although, the optimal format in which to communicate these probabilities requires further research.

Competing interests None.

Contributors AP had the original idea and designed the study. NP and GK undertook the literature review and analysis. SH developed the statistical methodology. All authors contributed to writing the paper.

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What is already known on this subject

- Many parents actively discourage their child's participation in school rugby due to injury and safety concerns.
- Communication of risk in sport is an underdeveloped element of injury risk management.

What this study adds

Population injury incidences can be transformed into probabilities of injury, providing parents and players with an alternative measure of injury risk.

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Notes