The relationship between team-level and league-level injury rate, type and location in a professional football league.

Abstract

Objective: To describe the relationship between team- and league-level variability of injury rate, type, and location over 6 seasons in professional Australian football (A-League). *Design:* Prospective epidemiological study. *Method:* Injury incidence, type and location were collected from all A-League teams (n=10) for 6 consecutive seasons (2012/13 to 2017/18) via a standardised injury surveillance system. Intra-class correlation (ICC) and coefficient of variation (CV) were calculated to assess the between-season variability of injury measures for each team. To determine the relationship between team-level injury variability on league-level injury rates, Marginal Coefficient of Determination (R^2m) to Coefficient of Determination (R^2c) were then calculated from generalised linear mixed models. This allowed determination of between season trends, where league-level injury incidence, type- and location rates were the response variables, season as the predictor variable and teams as random intercepts. *Results:* The majority of teams showed poor to moderate correlations for between-season injury rates (ICC: r=0.319-0.831), but also showed low-moderate variability between-seasons for injury rate (CV 34±22%). League injury rates were stable in most seasons, though was reduced in 2015/16 compared to 2012/13 (β=0.738; p=0.011). Joint/Ligament was the only injury type to have a coinciding significant reduction in 2015/16 (p=0.001). The model variance showed the reduction of Joint/Ligament injuries was league-wide rather than team-specific (R^2m=0.23; R^2c=0.23). *Conclusion:* In the A-League, low between-season injury rate variability from teams contributed to a stable league-level injury trend over seasons. A reduction in league injury rate in 2015/16 was mirrored by league-wide Joint/Ligament injury rates, without specific effect by team.

Key Words: Soccer, Team sport, Injury Incidence, Injury epidemiology

Practical Implications:

- Generalisation of league-level injury trends to a team-level should be applied with caution by governing bodies when informing policy.
- Between-team variability of injury incidence is high, and does not explain league-wide injury trends, hence analysis of underlying variability of league-level injury trends may be required by governing bodies.
- In the A-League, a league-wide joint/ligament injury reduction was evident, requiring further evaluation of the effect of league-wide risk reduction processes.

Introduction

Reporting injury epidemiology in professional association football leagues is deemed important to understand the nature and magnitude of the injury problem.[1,0] Such reporting can guide league-level medical policies that set the standard of medical provision and infrastructure expected of teams within a league.[2] To do this, injury incidence is often derived by aggregating players into a team-level rate to address injury monitoring issues associated with cost and time.[3] However, previous literature suggests that injury trends (overall or categorised by type or location), reported at a team level may not represent, if not contrast with, observations at a league-level; thus, caution is required when generalising findings between levels of analysis.[4,5] Hence, implementing league-level policy based on team-specific injury data could provide misleading outcomes.[3]

For governing federations, it is imperative to understand the relationship between team- and league-level injury analyses to better inform policies on injury reduction and prevention in football..[11] Historically, league-level injury epidemiology studies often assume that teams within a league are homogenous, ignoring inherent differences in the manner they reach successful (or unsuccessful) performance outcomes.[5,6,7] Hence, generalisations drawn from the league-level on medical policy and injury prevention research may not hold true for individual teams or players.[8] Conversely, the existence of volatile trends in injury rate, type or location at the team-level may be masked by stable league-level injury incidence reporting.[9,10]. Currently an understanding of both team-level injury variability and its relationship with league-level rates remains to be elucidated.

At a league-level, stable injury incidence rates are reported in a range of professional football leagues, though when injury trends when reported by type and location, they hint at underlying variability at a team-level that may not represent league-level injury rates.[9,10] For example, the UEFA injury studies report that muscle injuries remain stable ($\beta=-0.013$, 95% CI −0.032 to 0.005, p=0.138) whilst ligament injuries decreased ($\beta=-0.040$, 95% CI −0.065 to −0.016, p=0.005).[5] Further, hamstring ($R^2=0.431$, $\beta=1.023$ (95% CI 0.006 to 0.041), p=0.015), hip and groin injuries ($\beta=0.98$(95%CI:0.97 to 0.99), p=0.003) have increased.[12,13] These contradictory injury-specific directional trends contrast with the reported overall stable league injury rates. This possible misleading situation is of concern for governing bodies who interpret league-wide injury data to inform policy for individual clubs that make up a league. Therefore, evaluating the league- and team-level injury trends concurrently may provide better understanding on the relationship between team-level injury types and location and their influence on overall league-level injury trends.[8]

The accuracy of how injury epidemiology reflects the league-level injury landscape is often overlooked in football. Further contextual understanding of injury rates beyond the mean (of injury or clubs) may guide more refined understanding of injury concerns. Therefore, the aim of this study is to describe the influence of team-level variability on overall league-level injury rates, and by type and location, over 6 seasons in the Australian professional football league (A-League).

Methods

In 6 consecutive seasons of the A-League (2012/13 to 2017/18), physiotherapists from each club (n=10) submitted weekly injury data via Football Australia's Injury Surveillance spreadsheet to the Injury Surveillance Officer. Each season consisted of 27 matches (October to April) from the professional A-League competition, equating to 810 matches played, during which 421 players sustained 916 injuries. A release of medical records form was signed by each player as part of their A-League contract and permission of data usage was granted by Football Australia. The study design was approved by the Human Research Ethics Committee (ETH18-2324). Compliance to data entry was 100% due to injury surveillance as a legal obligation under the Professional Footballers Australia Collective Bargaining Agreement for all A-League licenced clubs.

The event of an injury and injury type and location characteristics was recorded in the Football Australia Injury Surveillance spreadsheet by a full-time team physiotherapist. To ensure high reliability of injury data, practitioners liaised with the injury surveillance officer regularly and received written methods and definitions with the injury surveillance proforma that could be accessed at any time. All physiotherapists were to submit injury data on a weekly basis. Injury was defined as 'any physical complaint requiring medical attention resulting in a missed A-League match'. Within the injury proforma, definitions of injury and the categories of type and location were adopted from the F-MARC Injury Consensus Group statement with the Orchard Sports Injury Classifying System – 10.[14,15] Individual athlete data was summed for each team and season.

Statistical Analysis

All statistical analysis was completed using R Statistical Package with lme4, sjstats, MuMIn.[16,17,18,19] There were three methods used to investigate the relationships between team- and league-level injuries. Firstly, team-level between-season injury rates are assessed using intra-class correlations (ICC), and secondly, between-season team-level coefficients of variation (CV). To determine the between-season variability of the league injury rate, a subset of the injury data was manipulated into wide format with each team as new variables and season injury rate for each row. Interpretation of between-season ICC was adopted from < 49% considered as poor, >50% indicating moderate, >75% is good, and >90% is considered excellent correlation of the injuries over 6 seasons.[20]

To further understand the relationship between team- and level-injuries, generalised linear mixed models were used to estimate injury rate as the response variable over 6 seasons. Teams were taken up as the random intercepts to explain the model error. Analysis of Covariance was used to compare the full specified models to the null model. Akaike Information Criteria (AIC), degrees of freedom, Chi-Squared and related p-value (alpha at $p<0.05$) was used to assess the fit of the models (Table 1). Between-team variability was assessed by comparing the Marginal Coefficient of Determination (R^2m) to Coefficient of Determination (R^2c) to determine the proportion of explained variance with and without specified random intercepts.

A second subset of the data was manipulated so that each injury-type and injury-location are new variables and each row is the season injury rate. Generalised linear mixed models were run where data permitted. Each subset of injury type and location as the response variable, where season was entered as the fixed effect and team as random intercepts.

Results

Between-season ICCs and CVs calculated for each team are reported in Table 1. There were 5 teams where singularity was observed, and ICC could not be computed. As a result, there were 2 teams with poor correlation, 2 with moderate correlation and 1 with good correlation based on between-season ICCs (Table 1). Coefficients of variation for team-level between season injury rates were (mean±SD) 34 ±22% (Table 1).

Seven generalised linear mixed models were run for league injury rates, injury type rates and injury location rates; 2 of which were significantly different from null models (Table 2). The model whereby league injury rates is the response variable was significantly different from the null model (p=0.019), with team injury rates explaining 23% more of the model variance. The model whereby joint/ligament injury rates are the response variable was significantly different from the null model (p=0.005); however, random intercepts for teams did not provide any more explanation for the model variance. All other models were not significantly different compared to null models (p>0.05; Table 2).

Back-transformed coefficients of the two significant generalised linear mixed models identified from likelihood ratio testing in Table 2 are reported in Table 3. The league injury rate was significantly reduced in 2015/16 compared to season 2012/13 and 2014/15 (p=0.011 and p<0.001, respectively). Similarly, Joint/Ligament injury rates reduced from 18 per team 2014/15 to 12 per team in 2015/16 (p=0.001). All other injury type and locations analysed remained stable across the 6 seasons.

Discussion

This is the first soccer injury epidemiology study to investigate the variability of team-level injury that underlie the overall, by type and by location league-level injury rates. The key findings showed team-level injury rate generally followed a similar stable injury trend, as observed by low between-season CV's, despite the poor to moderate ICC's over these 6 seasons. Further analysis of multi-factor distribution of injuries of a particular type or location between-seasons identified joint/ligament injury rates concomitantly decreased in the season with reduced league-wide injury rates (2015/2016). However, between-team variance did not explain the error in the joint/ligament model, suggesting that the effect was only at the league-level. Together, these findings provide further context that the team-level injury trend is stable and underlies the stable league-level injury trend in the A-League.

The present study investigated the intra-class correlation and coefficient of variation to understand the team-level variability in injury rates over the 6 A-League seasons. The poor to moderate ICC of injury rates, as well as half of the team's ICC unreportable due to singularity, existed alongside low between-season CVs, suggesting injury rates were not erratic between seasons in teams. Together, the low correlations and CVs of between-season injury rate highlight low variation from the mean of injury at the team-level, which would support the stable league-level injury rate trends noted here and in previous A-League injury epidemiology.[21, 22]. However, it must be highlighted that findings of the present study cannot assume low variance of injury epidemiology in teams in other football leagues and warrants future analysis of injury epidemiology with a prospective focus on team differences.

Accurate interpretation of football injury epidemiology relies on understanding the limitations of analysing singular team versus league-wide data.[23] In the current study, the 6 season league injury rates were stable, which compares favourably with other European and Japanese leagues.[9,10] In 23 UEFA teams, injury incidence (i.e. training and match) remained stable at 8.0±3.4/1000 h of playing exposure.[10] From 1993 to 2007, Aoki et al.[9] reported Japanese professional league injury rates between 19.11 (16.51-22.01) - 24.37 (21.12-27.99). Neither of these previous studies considered team differences that may influence these trends. In the present A-League data, team differences in the league Joint/Ligament injury trend explained 23% of the model variance. Hence, inherent differences between teams may be an idiosyncratic factor, and generalisation of injury incidence should be carefully applied between levels of analyses, despite similar and stable overall injury rates at both the team and league levels.

Cross-tabulation of injury characteristics can contextualise the injury situation and guide focus of injury prevention.[23] The present study suggests there was a league-wide reduction of joint/ligament injuries in 2015/16, as opposed to a reduction driven by a single team. This finding may be related to league-wide implementation of injury prevention, such as competition rules and regulations. In an earlier A-League injury epidemiology study between 2008/09 to 2012/13, Gouttebarge, Schwab & Kerkhoffs[21] mentioned that a significant reduction in total injury count was evident following the implementation of the 'Minimum Medical Standards'. At the time, this policy mandated a level of expected medical provision and infrastructure within clubs, aiming to reduce the number of injuries in the A-League. In the current data, during season 2015/16 a specific focus in the Minimum Medical Standards existed for Anterior Cruciate Ligament injury prevention awareness, which coincided with the transient reduction in injury rates. Although muscle/tendon injuries are the most common type of injury in the A-League, joint/ligament injuries decreased significantly in the same season (2015/16) where a reduced league injury rate was observed. Comparatively, in the UEFA Champions league studies, Ekstrand et al.[5] reported stable muscle injuries whilst ligament injuries decreased significantly. Although differences between teams had a 60% influence on ligament injury incidence in the UEFA study,[5] all teams had a similar reduction in joint/ligament injuries in the present study. However, it should be noted Ekstrand et al.[5] only reported from the top 4 'core' teams participating in all seasons between 2001 and 2012 (Arsenal FC, FC Internazionale Milano, PSV Eindhoven, and Real Madrid CF) in their multilevel model. Nonetheless, in our A-League data, a reduction in league injury rate was concomitant with reduced league-wide joint/ligament injuries as inferred by no further explained model error. Such findings can inform future injury prevention research and interventions for league-level stakeholders.

Despite the novel relationships reported here, some limitations need to be acknowledged. Bahr & Holme [24] recommended that injury epidemiology requires 20-50 injuries cases to detect moderate to strong associations or 200 injury cases to detect small to moderate associations. The injury rate in this study was 16.2 (95%CI:13.4-19.4) injuries per team per season and may not be sufficient to detect differences between teams.[25] Additionally, the injury definition only captures events that result in missed competitive A-League matches, which may underestimate the number of injuries that occur in training and do not result in a missed match. That said, Orchard & Hoskins[26] postulate a better correlation of 'match-loss' injury definition exists for comparing between and within teams and seasons.

The likelihood of ecological bias increases when there is low variability in exposure.[3]That is, the injury exposure in this study was standardised to 27 matches per club in each season resulting in overestimating variability in categories of lower injury rates. Exposure measured by hours and injury incidence reported per 1000 hours of playing exposure would reduce bias and allow for comparable injury incidence to studies following the Fuller et al.[14] injury epidemiology consensus statement. Injury burden (i.e., prevalence and severity of injury) was not considered for analysis due to the lack of time-loss due to injury data available in the dataset. As mentioned previously, cross-tabulation of injury events may provide another dimension of reflecting the state of injuries which may hint possible aetiology.[27,28] However, injury burden may overestimate injury severity due to this study's match-loss injury definition. Nonetheless, variability underlying injury burden should be considered in future studies using a smaller exposure unit of analysis (i.e. per 1000 hours of playing exposure).

Conclusion

Accurate interpretation of injury epidemiology is crucial for efficient benchmarking and evaluation of the injury situation in a team or league. The evaluation of league injury variability provides further interpretation of the injury situation as opposed to a limitation of injury epidemiology. In the A-League, stable team-level injury rates can partly explain stable league-level injury trends. A league-wide concomitant reduction of overall league injuries only with Joint/Ligament injuries in 2015/16 reinforces national federation approaches that all teams should prioritise injury prevention in their players.

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Table 1. Interclass correlation coefficient (ICC) and Coefficient of Variation (CV) reported for overall injury rates, injury rates by type and injury rates by location.

	ICC (r)	CV (%)
Team		
A	0.831	82
B	-	29
C	0.319	28
D	-	17
E	0.451	40
F	0.610	47
G	0.589	38
H	-	15
I	-	11

Table 2. Likelihood Ratio Test comparing full models estimating the overall-,individual type-, and individual location-injury rates over 6 seasons and comparison of marginal (R^2m) to conditional (R^2c) R-squared.

Model	Df	AIC	Chisq	P value (α=0.05)	R^2m	R^2c
Overall Injury Rates						
Null: Injuries ~ 1 + (1 | Team)	2	395				
Full: Injuries~ Season + (1 | Team)	7	392	13.467	0.019*	0.144	0.371
Injury Types						
Null: Muscle/Tendon ~ 1 + (1 | Team)	2	348				
Full: Muscle/Tendon~ Season + (1 | Team)	7	352	6.277	0.280	0.081	0.218
Null: Joint/Ligament ~ 1 + (1 | Team)	2	263				
Full: Joint/Ligament ~ Season + (1 | Team)	7	256	16.974	0.005*	0.233	0.234
Injury Locations						
Null: Hip/Groin ~ 1 + (1 | Team)	2	187				
Full: Hip/Groin ~ Season + (1 | Team)	7	191	5.757	0.331	0.094	0.100
Null: Knee ~ 1 + (1 | Team)	2	188				
Full: Knee ~ Season + (1 | Team)	7	195	1.507	0.912	0.024	0.065
Null: Lower Leg/Achilles Tendon ~ 1 + (1 | Team)	2	169				
Full: Lower Leg/Achilles Tendon~ Season + (1 | Team)	7	177	2.017	0.847	0.031	0.102
Null: Thigh ~ 1 + (1 | Team)	2	251				
Full: Thigh ~ Season + (1 | Team)	7	260	0.491	0.992	0.007	0.123

Table 3. Back-transformed coefficients from significant generalised linear mixed models identified from likelihood ratio tests.

Model : Injuries~ Season + (1 | Team)				
Fixed effects:				
	Estimate	Lower CI	Upper CI	P value (α=0.05)
(Intercept)	16.206	13.407	19.424	<2e-16
2013/14	0.927	0.743	1.156	0.499
2014/15	1.110	0.899	1.371	0.333
2015/16	0.738	0.582	0.932	0.011*
2016/17	0.896	0.717	1.120	0.335
2017/18	0.915	0.733	1.141	0.429
Random effects:				
	Groups	Name	Variance	Std.Dev.
	Team	(Intercept)	1.025	1.169

Model : Joint/Ligament Injury Rate ~ Season + (1 | Team)				
Fixed effects:				
	Estimate	Lower CI	Upper CI	P value (α=0.05)
(Intercept)	5.299	3.984	6.860	< 2e-16
2013/14	0.774	0.512	1.160	0.217
2014/15	0.981	0.668	1.440	0.922
2015/16	0.491	0.302	0.776	0.003*
2016/17	1.048	0.711	1.543	0.811
2017/18	0.629	0.397	0.977	0.042
Random effects:				
	Groups	Name	Variance	Std.Dev.
	Team	(Intercept)	1.000	1.022

2012/13 = reference season; * significantly less than 2012/13