Title: Bradford Factor and seasonal injury risk in Division I-A collegiate American footballers

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ABSTRACT

Purpose: To investigate if participation in a higher percentage of pre-season sessions affects the injury profile within Division 1-A American Collegiate and whether the Bradford Factor (BF) is viable for practitioner use.

Methods: A retrospective research design was used. Training load and injury data were collected and analysed for two collegiate American football seasons for 70 players.

Results: A total of 184 injuries were sustained across two seasons with 106 resulting in time loss (15.6±5.4 time loss injuries per 1000 hours). On average athletes completed 93±17% of pre-season sessions. For injury likelihood in the following week an increase in accumulated minutes in 7d increased the injury risk 35%. For non-contact time loss injuries, pre-season completion showed a reduction in injury likelihood of 2% for an additional 3 sessions completed. A high BF in pre-season (>7) increases the risk compared to a low BF through the in-season period.

Conclusion: Pre-season completion was not associated with a substantial reduction in injury risk in-season. A clear difference in BF between groups was evident and may provide a practical 'flagging' variable. The BF may provide a simple but practically meaningful measure to monitor adaptation.

Introduction

Collegiate American football is a team sport characterised by frequent high-intensity movements and high–impact collisions[1]. Given the nature of the sport, players are at risk of being exposed to injury. It has also been shown that factors such as position and experience influence injury risk.[2] Regardless of risk factors, injury rates in collegiate American football are higher in the pre-season period[3]. This pre-season period is represented by an intensified pre-season training camp performed over a period of approximately 4 weeks prior to the first competitive event (game) of the season.

For many teams, the first week of pre-season camp represents an acute, and often, significant increase in training load. For instance, a recent study has shown that accelerometer-derived player load (PL) for the first week of pre-season was significantly higher for those that had full participation when compared to their cumulative PL for every in-season week[4]. This outcome contrasts progressive recommendations for training load provided to mitigate injury risk[5] and optimise athlete preparation prior to the commencement of the NCAA Division I American football. Therefore, it would appear the pre-season period encompasses a period of high stress and risk for player injury. However, within American Football this has not been examined with reference to its subsequent effect on the in-season period.

In other contact sports it has been shown that completing a greater percentage of the pre-season lowers the risk of injury in season (OR=0.83)[6]. For example, within Australian football, players who participated in >85% of pre-season training sessions were likely to have increased in-season availability.[7] Taken together, this research suggests that a greater training load, particularly in the pre-season preparation phase can increase resilience and subsequently affords greater player availability in-season – whether this holds true in American Football is not yet known. It would seem understanding this relationship would aid athletic preparation for the sport.

In a sporting context, the accumulation of small periods of missed training may be just as impactful as long periods out to injury. As a practical example, in collegiate American football, missed periods of training may reduce time learning offensive and defensive schemes. Indeed, we believe this absence of consistency in training could potentially lead to underperformance. We believe that such a premise may have been underappreciated in time gone by in team sport performance, and as a potential mechanism to combat this issue one may quantify this relationship using the Bradford Factor (BF), which is commonly used in human resources to monitor absenteeism (1);

$$\text{BF} = (\textit{number of absences})^2 \times \textit{total days of absence} \quad \textbf{(1)}$$ [8]

Whilst relatively blunt, the BF may thus effectively highlight the disruptive nature of repeated short-term absences by weighting the number of absences more so than the accumulated days of absence. It has been suggested that this is applicable in sports to manage training loads[9] as every time-loss event may affect one's ability to resume the pre-injury training load.

This investigation aims to see if participation in a higher percentage of pre-season sessions affects the injury profile within an American Football season and if the Bradford Factor is a viable marker for highlighting at risk individuals to practitioners.

Methods

Subjects

Seventy players (20.7±1.5 years) from a Division 1A NCAA team were assessed across two consecutive seasons (Season 1, n=44; Season 2, n=48), including 22 subjects that participated in both seasons. Players provided written informed consent indicating that de-identified performance data may be used for research. The University Research Compliance Services approved all experimental procedures.

Design

A retrospective analysis of two regular 16-week NCAA Division 1 American Football seasons' weeks (four-week pre-season camp with 12 in-season weeks) recorded as part of standard athlete support was performed. Injury surveillance was performed over the entirety of both seasons with all injuries diagnosed and recorded by certified university athletic trainers and confirmed or amended by licensed medical staff. On-field training exposure was recorded in minutes for each player. The data analysed consisted of all practice sessions during two consecutive seasons' four-week pre-season; and the three primary weekly practice sessions and game day during the in-season periods. For the purposes of the present study, an injury was defined as any physical complaint reported to athletic training staff by a player regardless of whether it resulted in time-loss or not (missed training or games). Injuries were further analysed if non-contact time loss injuries (at least one missed training session or game due to the injury). Injury incidence was calculated as the number of injuries per 1000 participation hours.

Methodology

Preseason attendance

Non-participation in training was listed as 'did not practice'. Players' individual preseason participation levels were quantified as the percentage of the maximum possible completed.

External load

Players were fitted with an inertial measurement unit (IMU) during training and match activities (Optimeye S5; Catapult Innovations, Melbourne, Australia). Devices were inserted into a custom-made pouch and attached between the scapulae of the players' shoulder pads. Each player used the same IMU device each day. Playerload^{TM} (PL) was calculated for each training session using a customised algorithm within the software provided by the manufacturers (OpenField 1.11, Catapult Innovations, Melbourne, Australia). Briefly, this parameter represents the square root of the sum of the squared instantaneous rate of change in acceleration within the three planes divided by 100 (Catapult Innovations, Melbourne, Australia).

Impact of absence

BF was calculated from the number and frequency of absences as a rolling total from season start.

Statistical Analysis

All data were analysed in the open-source statistical software, RStudio (V.3.4.2). Independent random effect (multilevel) logistic regression models were fitted for each independent variable using the R's *lme4* package, with the likelihood of sustaining either an injury or a non-contact time-loss injury as the outcome variable, and random intercepts for each player. These models were used to determine which variables were associated with an increased or decreased risk for injury throughout the season, not controlling for other covariates. In fitting the regression models, all training load variables were standardised owing to the different scales of the measures and subsequent failure of the models to converge in the statistical software with unadjusted predictor variables. Odds ratios (OR) were calculated to determine the effect size associated with a 1 SD increase in training load variables. Statistical significance was set at $p<0.05$ for all analyses, and ORs were calculated as an effect size for all models. BF differences were assessed based on Hopkins effect sizes.[10]

Results

A total of 184 injuries were sustained across two seasons with 106 resulting in time lost (15.6±5.4 time loss injuries per 1000 hours). 32% of those injuries occurred in the pre-season (25% of the season). 53 of all injuries were non-contact time loss injuries. On average athletes completed 93±17% of pre-season sessions.

A 1SD increase in accumulated minutes in 7d increased the injury likelihood in the following week 35% (929 minutes).

For non-contact time loss injuries, pre-season completion may result in a reduction in injury likelihood for an additional 3 sessions completed, though the result is not clear (Table 1). The average PL and injury incidence during each week of the competitive season are displayed in Figure 1. Looking at the injury risk during the in-season period across a week, results show that a BF in pre-season >7 increases the risk of injury in-season compared to a BF <7, (Figure 2). The associated pre-season completion rate for these groups showed a meaningful practical difference (81% *v* 97%; ES = -1.1). The average BF for pre-season completion is also illustrated in Figure 2.

Discussion

It is clear that the season design within collegiate American football does not follow best practice as the highest loads occur in the first two weeks of the pre-season period (Figure 1). Within this group of American Football collegiate athletes, pre-season completion was not associated with a substantial reduction in injury risk in-season. Interestingly, a clear difference in BF between groups was evident, which may provide practitioners with a ‘flagging’ variable that can indicate a need to intervene (BF>7 in pre-season; BF>80 in-season).

The lower risk observed in athletes in-season that completed more pre-season sessions may reflect a ‘survival of fittest’ amongst those genetically pre-disposed to cope effectively and recover from high loads without an injury event. Conversely, it may be that an increased exposure to training may develop an ‘injury resiliency’ effect. That is, the increased risk with lower training exposure is in-keeping with the training literature that suggests high chronic loads are protective[11]. Further studies are needed to confirm this across multiple teams.

Logistically this training design may occur as there are external restrictions on the periodisation model. The pre-season period is limited in length and session number.[12] This may inhibit the ability of athletes to adjust to sport specific conditioning and learning in conjunction with building up a resilience.

Practical Implications

The BF may provide a simple but practically meaningful measure, similarly to sRPE, to monitor adaptation as it adds weight to the number of absences. This objective approach ensures that all athletes are treated similarly although some coaches may take different approaches with monitoring loads within American Football based on player status[2]. The BF may be a useful addition to the practitioner’s toolbox in conjunction with other measures of load as it tracks the costs of injuries in terms of lost practice time and likely increased involvement of training staff.

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Table Captions

Table 1: Association of variables with injury likelihood in the subsequent week for injuries per se and non-contact time loss injuries**.**

Figure Captions

Figure 1: Average daily load per player and total average team injury incidence per 1000 hours during the season

Figure 2: Predicted injury risk in season (all injuries) based on Bradford Factor within pre-season period. High Bradford Factor was >7 and low <7 based on medium and low completion rates in pre-season being associated with a Bradford Factor under 7.