Abstract

Objectives: This study primarily aimed to explore injury incidence rates in the three main domestic competition formats in England and Wales (First-Class, One-Day and Twenty20 [T20]). For the first time, the study also describes the epidemiology of elite men's domestic cricket injuries across nine seasons (2010 – 2018 inclusive).

Design: Prospective cohort analysis.

Methods: Injury incidence and prevalence from all injuries calculated according to the updated international consensus statement on injury surveillance in cricket, with statistical process control charts (SPC) used to detect trends in the data.

Results: The average match injury incidence was 102 injuries/1,000 days of play, with highest incidence in One-Day (254 injuries/1,000 days of play), followed by T20 (136 injuries/1,000 days of play) and First-Class Cricket (68 injuries/1,000 days of play). Most match injuries were sustained during bowling (41.6 injuries/1,000 days of play), followed by fielding (26.8 injuries/1,000 days of play) and batting (22.3 injuries/1,000 days of play). The thigh was the body area most commonly injured (7.4 injuries/100 players per season), with lumbar spine injuries the most prevalent (1.3% of players unavailable on any given day during the season). On average, 7.5% of players were unavailable on any given day during the domestic season when all injuries were considered (match and training). The SPC charts showed relatively consistent match injury incidence for all competitions, reproduced across all nine seasons.

Conclusion: These findings provide a robust empirical base for the extent of the injury problem in domestic cricket played in England and Wales, with similar injury profiles across the three formats.

Key words: epidemiology; incidence; prevalence; sports

Practical implications

- Findings from the largest formal analysis of men's domestic cricket injuries in England and Wales to date, generally support previous international cricket research adding to the empirical base for specific injury risks associated with this sport.
- Potential unique injury profile associated with T20 cricket highlighted that may warrant further investigation.
- Introduction of Statistical Process Control charts for identification of injury trends showed consistent rates. Continual use can monitor any subsequent injury prevention strategies.

1. Introduction

An important aim for injury surveillance in any sport and indeed cricket, is to identify the injury types that pose the greatest threat to availability to inform and evaluate targeted injury prevention and management initiatives. Understanding the current injury situation is the first phase in O'Brien et al's[1] three phase cycle for team-sport injury prevention. Once this has been established, injury risk factors and mechanisms are identified in the second phase, which can then inform preventative strategies introduced in the third and final phase. To effectively fulfil this aim, enough longitudinal data is ideally collected from the same setting,[2] reducing any potential confounding variables that may arise when comparing general trends between settings and the different conditions associated with each unique environment. This has been possible in Australia, where injury surveillance has been ongoing since 1995.[3, 5] However, to date there is a lack of published research describing the magnitude and nature of injury risk in England and Wales domestic cricket, despite this setting representing a large proportion of elite cricket played worldwide.

In 2005, an international consensus statement was published outlining recommended methods for injury surveillance in cricket, with the aim of enabling comparison and improving the consistency and quality of research in the field.[6] The guidelines were initially used in several settings detecting a number of common injury trends, such as high incidence of hamstring strains, higher incidence in One-Day limited

over cricket compared to other competition formats, a greater injury risk for fast bowlers over other player types/disciplines and high prevalence of lumbar spine injuries.[3-5, 7] However, the injury incidence units (per 10,000 player hours) used in these studies were not suitable for comparing competition formats to a shorter format of the game (Twenty20 [T20] cricket), which emerged and became increasingly prominent after the consensus was published.

First-class matches are, typically scheduled for four days (approx. 24 hours of play per match in comparison to 2.5 and 7 hours for T20 and One-Day matches respectively), and even though there has been shown to be a higher number of injuries per first-class match, the hourly injury rate is lower than other competition formats.[8] To enable more appropriate comparison, it was proposed match injury incidence should be reported in days (per 1,000 player days) as opposed to hours.[8] This change was consolidated with its inclusion in the updated international consensus statement on injury surveillance in cricket, which also included a broader injury definition as well as definitions for; mode of, and activity at time of injury.[9] However, to date only one study from Australia has employed the updated recommended injury surveillance units and included T20 cricket when assessing competition format as an injury risk in the men's game.[5] Notably, the authors acknowledged due to the lack of international T20 matches in some seasons, international and domestic level injury rates were combined for T20 cricket, limiting comparison with other competition formats where international and domestic injury rates are reported separately. Since higher injury incidence and prevalence have been found at international compared to domestic cricket,[3-5, 7] different competitive levels should be analysed and reported independently to enhance the validity of the findings.

Accordingly, the primary aim of the present study is to compare match injury incidence between domestic competition formats in England and Wales, along with seasonal injury epidemiology and trends between 2010-18, to determine the priority injury problems and inform and evaluate associated injury management initiatives.

2. Methods

This prospective cohort study included all registered male players from the 18 First Class County Cricket (FCCC) clubs in England and Wales who have been involved in the England and Wales Cricket Board (ECB) injury surveillance programme (mean n = 507 players per season), encompassing the domestic competition season from April to September from 2010 through 2018 inclusive.

All injuries were recorded by FCCC club's medical staff, most often the lead physiotherapist on a purpose built central online medical records systems: Profiler (The Profiler Corporation, New Zealand, 2010-2016 inclusive), and Cricket Squad (The Sports Office, UK, 2017-2018 inclusive). To improve compliance, the ECB mandates consistent standards for injury and medical record-keeping for the domestic game through annual Cricket Science and Medicine Audit. Included in the medical record for each injury, the squad physiotherapists and/or Club Medical Officer records the injury location and diagnosis based on the Orchard Sports Injury Classification System Version 10,[10] as well as cricket specific activities at the time of onset.

Before the ECB shared the injury surveillance data with the University research partner, the data was anonymised and checked for any errors by the ECB Injury Surveillance Officer who removed any identifiable data and assigned numerical IDs to players and injury records. Errors in the data included duplicate records and injures recorded that either remained open or needed updating or contained discrepancies, such as the body region recorded not matching the selected Orchard code). Such records were investigated by the ECB Injury Surveillance Officer (who is a trained physiotherapist with applied medical experience) and if needed, checked with the relevant practitioner or club who recorded the injury and updated accordingly. Any duplicate records were removed. All players provided informed written consent for their data to be routinely collected and analysed by ECB and a University research partner, arranged in conjunction with the players' union, The Professional Cricketers Association' (PCA). This was done at the time of annual registration and reviewed if there were any significant process or contractual changes at the start of pre-season. Ethics approval was obtained from the University of Bath, Research Ethics Approval Committee for Health (REACH).

The definition of 'injury' in the updated consensus on cricket injury surveillance is inclusive of illness[9] and in line with these guidelines, First-Class County practitioners defined and recorded any injury or

105 illness that was considered to render the player unavailable for match selection, regardless of whether
106 a match was scheduled on the day(s) the player was unavailable.

107 Injury incidence and prevalence was calculated following guidance in the updated consensus and to
108 enable comparison to previous research, two injury incidence units are used, both applied
109 retrospectively:

110 1. Match injury incidence includes all new and recurring (injury of the same type, on the same
111 side, in the same body region, in the same season as an injury from which a player has
112 previously recovered)[9] match injuries reported for all phases (batting, bowling and fielding). It
113 considers only injuries occurring during major matches[9] and is provided for each competition
114 format and then body region and activity at time of injury with the unit of injuries per 1,000
115 days of play.[5]
116 2. Seasonal injury incidence is calculated from all new and recurring injuries per 100 players per
117 season (183 days each domestic season) and allows for match and training injuries to be
118 contained in one measurement. The consensus statement recommends the incidence unit of
119 'annual injuries per 100 players per year',[9] but given the fixed six-month nature of the domestic
120 season in England and Wales, extrapolating the seasonal incidence to provide an annual
121 incidence did not seem appropriate as it over-estimated the extent of the injury situation for the
122 year. Particularly when there is distinct six-month off season for cricket in England and Wales
123 with a greatly reduced number of injuries. Consistent with previous research[5] and the consensus
124 statement,[9] seasonal injury incidence is reported by body region and includes 'Medical illness'
125 injuries.

126 Seasonal injury prevalence is presented as a percentage of players unavailable on any given day (i.e.,
127 not just match days, which would be 'match injury prevalence') by body region injured. With the ECB
128 injury surveillance programme injuries are recorded as and when they occur as opposed to a daily status
129 for each player. For this reason, the days lost recorded for each injury cover all seasonal days lost
130 regardless of whether there was a match or not and it is not possible to align fixtures to the duration of
131 the injury. Seasonal injury prevalence was calculated by the numerator of total missed seasonal days,

with a denominator comprised of the total number of days in the surveillance period multiplied by the total number of registered players.

Injury incidence and prevalence were summarised with descriptive statistics (mean and 95% Poisson confidence intervals [CI]). Significant differences were assumed if the 95% CIs of individual categories did not overlap.

Statistical process control (SPC) analysis and charts were also used to detect trends in match injury incidence for each competition format over the nine seasons. The chart is comprised of upper and lower 'control limits', that are one, two and three SD above and below the overall mean injury incidence. SPC Shewhart u-charts of injury rates provide a quantitative monitoring tool to detect statistically significant changes over time.[11] With enough data, it allows for the identification of special variation from a particular data point's own historic baseline. The use of supplementary 'signalling' rules (the most of common of which were originally proposed in the Western Electric Handbook)[12] can highlight the need for further investigation when a supplementary rule has been met. These supplementary rules are:

- One or more points outside of the calculated control limits
- Two out of three consecutive points beyond two SD from the baseline
- Four out of five consecutive points beyond one SD from the baseline
- Nine consecutive points on one side of the historical baseline

3. Results

Total days played (mean = 1,463) across all FCCC decreased in the seasons towards the end of the surveillance period, with the total number of registered players (mean *n* = 505 players per season) relatively stable across the nine years (supplementary table 1).

The highest mean match injury incidence was found for Domestic One-Day cricket (mean: 254 injuries per 1,000 days of play, 95% CI 231-280), followed by T20 (mean: 136, 95% CI 121-152) and First-Class cricket (mean: 68, 95% CI 63-74). All competition formats were combined to provide overall

match injury incidence for the activity at time of injury (supplementary table 2). Over the nine seasons, bowling consistently had the highest match injury incidence, followed by fielding and batting.

Bowling presented the highest risk of injury across the competition formats except for T20 cricket (supplementary tables 3-5) where highest match injury incidence was for fielding (followed by bowling). The one-day competition format presented the highest risk to bowlers with the highest average mean match injury incidence (104.5 injuries per 1,000 days of play). Thigh injuries had the highest match injury incidence across all competition formats (supplementary table 6) except for First-Class cricket where hand injuries (supplementary table 7) had the highest match injury incidence (followed by thigh injuries). Thigh, hand, abdomen and lumbar spine injuries were regularly in the top four injured body regions across competition formats, except for the shortest T20 format, where shoulder and ankle replaced abdomen and lumbar spine injuries in the top four injured body regions (supplementary tables 8-9). For all injuries over the season, the thigh was the most common body region injured (highest average time loss incidence), followed by hand and lumbar spine injuries (supplementary table 10).

General seasonal injury prevalence rates were relatively consistent over the nine seasons (supplementary table 11). Lumber spine injuries resulted in the most days lost with 1.3% (mean) of players unavailable on any given day during the season from lumbar spine injuries. On average, 7.5% of players were unavailable on any given day during the domestic season when all injuries were considered (match and training).

Match injury incidence was plotted on SPC charts for each competition format: One-Day (figure 1); T20 (figure 2); First-Class County Championship (figure 3). None of the supplementary 'signalling' rules were fulfilled, with the charts illustrating the consistency in injury incidence for each competition format for each domestic season between 2010 and 2018, suggesting the relative injury risk for each competition format was stable during this period.

182 Figures 1-3: Control charts for match injury incidence (per 1,000 days play) for One-Day (A), T20 (B), and First-
183 Class (C) cricket formats, for each season, with control line, upper and lower limits of 1, 2 and 3 SD from mean

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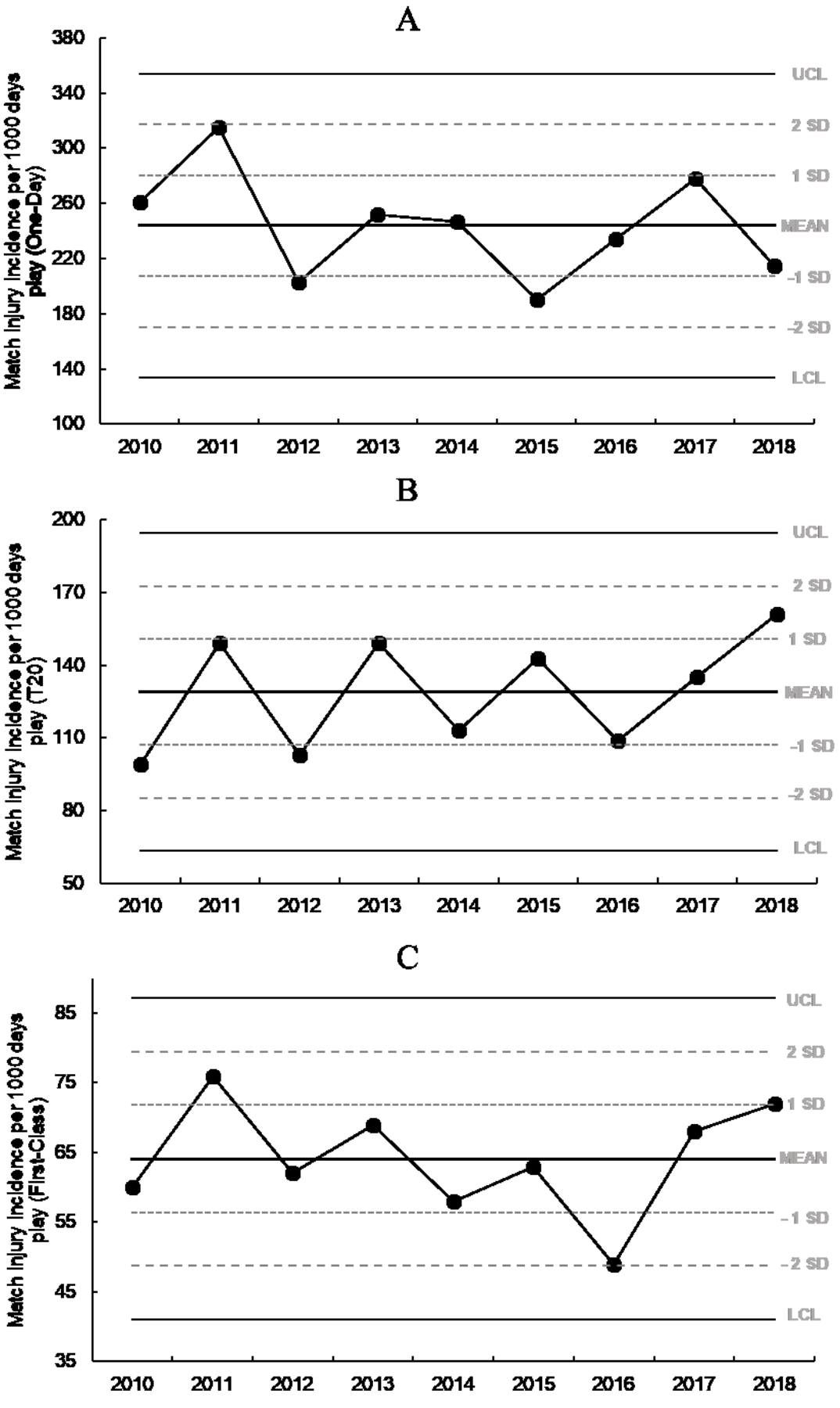

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4. Discussion

This is the first study to explore the injury epidemiology of elite male cricketers in England and Wales and represents the largest body of work to date on the injury epidemiology of elite domestic cricket. For the first time, SPC charts were applied to sport injuries to detect trends in match injury incidence for each domestic competition format. The main aim of the study was to determine how match injury incidence differs between men's domestic competition formats in England and Wales to determine the priority injury problems in FCCC that can inform and evaluate injury management initiatives. One-day limited over cricket (which went from 40 to 50 overs in 2014) had the highest match injury incidence, with incidence for competition formats relatively consistent over the nine seasons.

While it is not always possible to directly compare, the general trend of higher match injury incidence in domestic One-Day cricket is consistent with the findings reported in Australia, the country that has played the most comparable quantity of domestic cricket with injury surveillance established over an equally substantial time.[3, 5] None of the supplementary SPC 'signalling' rules were fulfilled indicating the lack of variation in the data. The 'control charts' provides injury trends in an understandable way for decision makers, with visual and quantitative representation of defined variations from baseline. Similar to their application in the Army,[11] SPC techniques could continue to be used in cricket to monitor and evaluate the effectiveness of any subsequent injury prevention strategies.

Injury profiles were generally similar across competition formats and consistent with previous research, with thigh injuries found to have the highest time loss injury incidence.[3-5, 13] In Australian cricket, fast bowling was shown to be the activity most associated with hamstring injuries,[14] due to increased sprinting compared to other roles as measured by Global Positioning System (GPS).[15] However, as more sprinting is required when fielding and batting in the shorter, more intense formats of One-Day and T20 cricket,[15-16] a rise in hamstring injuries has also been found for these positions in these formats.[16] This notion has been further reinforced with the results from this study that found fielding to be the activity resulting in the highest injuries in T20, with bowling highest in the other formats. Hamstring injuries are common in positions and sports involving high speed running, accelerations and decelerations.[17-22]

The high injury incidence of shoulder injuries (relative to other body regions) along with higher injury incidence when fielding than bowling in T20 cricket (relative to other activities) compared to other formats, is a unique finding to this paper. This was not found in the previous injury surveillance paper that included the T20 format,[5] although it must be noted this paper combined both international and domestic cricket in their T20 injury rates due to low number of international T20 games. Although relatively high shoulder and fielding injury incidence was found in the injury profile of elite women's domestic T20 cricket,[23] no previous research has focused on the injury profile of domestic men's elite T20 cricket and further research is needed to validate the potential unique injury risks this particular format may present.

The results of the current study further validate findings from previous research that has identified bowling as being the activity associated with the highest time loss injury incidence.[3-5,7,24] This is most often associated with fast bowling and the ability to explore potential differences in injury rates between fast and spin bowlers is beyond the scope of this paper but warrants future investigation. The biomechanical demands of fast bowling create a unique injury risk in cricket, resulting in bowlers being particularly susceptible to lumbar spine injuries, in part due to the extreme trunk lateral flexion postures required for this activity.[25] Identification of this specific injury risk from the injury surveillance data has enabled the ECB to focus their research on practical management programmes aimed at understanding and reducing this particular injury burden.[26-27]

Consistent with previous research, this study found lumbar spine injuries to have the highest prevalence,[3.5,7] which in Australia has been associated with high bowling workloads arising from the longer forms of the game.[5] Although the match injury incidence for lumbar spine injuries was highest for One-Day cricket compared to the other competition formats, the absolute number of injuries was highest in First-Class Cricket due to the increased exposure in this format. However, it is important to also consider squad size and player demographics may fluctuate year on year and are not factored in with this current study. Age has been shown to be an important risk factor in fast bowler lumbar spine injuries,[28] but specific injury trends and causation are not debated in this paper.

There are limitations with the injury surveillance data contained within this study. Injuries are entered predominantly by the club's medical staff, most often the lead physiotherapist. As with any injury surveillance involving human data entry, there is risk of error not just in the data entered but the maintenance and updating of records. Over time, processes have been introduced to reduce such potential error and provide some assurance in the validity of the data. Standardised processes and definitions set by the ECB and the international consensus statement should help in reducing potential misclassification bias but with 18 different clubs in the County Championship, this remains a small but tangible risk.

This study formally establishes the extent of the current injury problem in elite male domestic cricket for both incidence and severity, as outlined in phase one of O'Brien et al's[1] three phase cycle for team-sport injury prevention. Even though it seems injury incidence has remained stable over the nine seasons, this data has guided ECB research efforts into the second and third phase of identifying injury risk factors and introducing injury prevention strategies. Along with the aforementioned efforts to reduce the burden of lumbar spine injuries there have been practical changes to the game to enhance player safety. The identification of high injury incidence of helmet related facial injuries, which was only recognised from analysing data collated across all FCCC clubs, spurred the ECB to drive a change in international helmet safety standards.[29]

Future research should be guided by the continued need to identify injury risk factors and mechanisms that can inform injury prevention strategies, with the consistent injury rates highlighted in this study suggesting more work is needed to effectively reduce injury incidence across the domestic game. Based on these findings, which further validate previous research, priority should be given to thigh muscle and lumbar bone stress injuries, which have the highest incidence and prevalence respectively.

5. Conclusion

This study found One-Day cricket to have the highest time loss injury incidence rates, followed by T20 and First-Class County Championship in England and Wales. Overall, most injuries were sustained

whilst bowling, with hamstring injuries being the most common, and lumbar spine having the highest prevalence. Injury incidence and prevalence were relatively consistent for all injuries across the nine seasons. These findings provide a robust empirical base for the extent of the injury problem in domestic cricket played in England and Wales, which can continue to guide future research in identifying injury risk factors and mechanisms that can inform injury prevention strategies.

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Declaration of interest None.

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