Fast bowling match workloads over 5–26 days and risk of injury in the following month

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Objectives: This study examined whether high match fast bowling workloads in the short to medium term were associated with increased bowling injury rates.

Design: Prospective cohort study.

Methods: Over a 15 year period, workload patterns for 235 individual fast bowlers during time periods from 5 to 26 days were examined to consider whether there was an increased injury rate during the month (28 days) subsequent to the workload.

Results: Fast bowlers who bowled more than 50 match overs in a 5 day period had a significant increase in injury over the next month compared to bowlers who bowled 50 overs or less RR 1.54 (95% CI 1.04–2.29). For periods ranging from 12 to 26 days, there was no statistically-significant increase in injury over the next month from exceeding thresholds of certain amounts of overs, although bowlers who bowled more than 100 overs in 17 days had a non-significant increase in injury over the next month RR 1.78 (95% CI 0.90–3.50).

Conclusion: There were no statistically-significant increases in subsequent injury risk for high workloads for periods of 12–26 days, although exceeding 100 overs in 17 days (or less) was associated with higher injury rates. Compression of cricket fixtures is likely to have only a minimal contribution to increased fast bowling injury rates being seen in the T20 era (along with sudden workload increases due to transferring between forms of the game, which has been previously established as a major contributor).

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1. Introduction

Cricket is one of the world’s major team sports and the most popular sport in southern Asia, one of the world’s most populous regions. Broadly speaking, there are two major bowling types in cricket: fast bowling (also known as pace bowling) and spin bowling. For the purpose of this paper, the term ‘fast bowlers’ refers to bowlers who bowl fast, medium-fast or medium (i.e. deliveries with a fast run-up) as opposed to spin bowlers. At amateur level, cricket is a relatively safe sport with few injuries. Injury data from the New Zealand Accident Compensation Corporation (ACC), the national insurer for all sports injuries, show that cricket has only one fifth the injuries of football (soccer). Both sports have slightly over 200 000 participants in New Zealand, showing that at amateur level, cricket is a much safer sport than football. However, at professional level there are far more injuries, particularly non-contact (overuse) injuries amongst fast bowlers. All sports have the potential to demonstrate increases in injury risk as workload/level of competition increases. For example, jogging and swimming are relatively low-injury forms of exercise, but rates of injuries in elite triathlon competitors are higher than for recreational competitors.

Under the traditional international cricket schedule of years gone by, cricket was also a relatively safe sport at elite level, as there was only one form of the game (Test cricket over 5 days) with more lengthy breaks between matches and Test series. However the scheduling of cricket in recent years has expanded with three formats of the game and play for much of the year with shorter breaks. First class cricket matches (including Test matches, between countries) are played with unlimited overs lasting four or five days (with two innings per team). In these matches bowlers can sometimes be required to bowl 50 overs (300 balls) or more over the 4–5 days, depending
on the amount of time it takes to dismiss the opposition. One day matches are played with a maximum of 50 overs to be bowled in each team’s single innings, which each bowler being allowed to bowl a maximum of ten overs. T20 matches are similar to one day matches, with the limit on overs for each team being 20, and each individual bowler having a limit of 4 overs.

The prevalence of injuries in cricket has risen in recent years as the calendar has included more T20 cricket (from 2006 onwards—referred to as the “T20 era”). These scheduling changes are possibly related to injury rates, particularly amongst fast bowlers, at professional level becoming much higher in recent times.

Recent studies in soccer (football) have found that an increased number of fixtures in a compressed period of time is associated with higher than expected injury rates. Although there is variation between countries as to how much cricket is played, most countries have played a very similar amount of Test and ODI matches in the era since T20 cricket became popular. The inclusion of T20 matches and competitions in the cricket calendar, without a concurrent major reduction in first class or one day cricket, has had two effects on cricket scheduling and fast bowler workloads:

1. On multiple occasions in a season, fast bowlers who play both first class and T20 cricket must switch between formats and undergo very large variations in match bowling workloads (e.g. up to tenfold changes from 4 overs per match to 40 overs per match).
2. The calendar for First Class matches has become more congested. For example, since the early 1980s Australian domestic teams have played a regular season of 10 first class matches. Prior to 2006, these 10 matches were spread evenly over the 6 months from October to March (i.e. less than 2 matches per month). In the T20 era, first class matches are not scheduled during the limited overs competitions, which now take up almost half of the summer domestic cricket season. The 10 first class matches are now played in two blocks over 3–4 months in total, meaning an average of 3 first class matches per month.

A recent study has examined the risk to fast bowlers from rapid increases in workload and found fast bowlers with an external workload training-stress balance of more than 200% (i.e. rapid more than doubling of workload) had a RR of injury of 3.3 (95% CI 1.50–7.25, p = 0.033) in comparison to fast bowlers with an external workload training-stress balance between 50 and 99%. This demonstrates that the schedule of the T20 era creates more fast bowling injuries in part because the schedule change between T20 and first class phases lead to unavoidable sudden upgrades in match workloads between bowlers who play both T20 and first class cricket.

The aim of this study was to look at the other side of the equation in T20 cricket, to attempt to answer the question: does compression of First Class matches (i.e. playing First Class games in close proximity to each other) in itself increase injury risk in fast bowlers?

To attempt to answer this question, player match workloads over 15 seasons were examined, to see whether there was an increase in injury risk when exceeding certain workloads over a short time period. It has already been established that exceeding 50 overs in a single game increases the risk of injury. The risk of injury related to high and low weekly workloads over the course of a season has also been studied. However, we are not aware of increased risk being documented for fast bowler workloads exceeding certain amounts over periods of longer than a week but shorter than a month.

2. Materials and methods

Cricket Australia conducts an annual ongoing injury survey recording injuries in contracted first class players. Methods for this survey have been described previously. The methods used for Cricket Australia injury surveillance are non-interventional, conform to the Code of Ethics of the World Medical Association (Declaration of Helsinki) and have been approved by the Cricket Australia Sports Science Sports Medicine Advisory Group.

This study was a prospective cohort study comparing fast bowling injuries between high and low workload players over the 15 seasons 1998–99 to 2012–13 inclusive. Bowling injury and workload data were extracted from the pre-existing database in a de-identified fashion for the purposes of this study. The Australian Government National Health and Medical Research Council (NHMRC) considers observational studies of this nature with de-identified data to expose participants to ‘negligible’ risk.

In 2005, cricket researchers published consensus international injury definitions for the sport and the methods of this survey adhere to the international definitions. This study concerns fast bowling injuries only and therefore includes a dataset of injuries in fast bowlers sustained either with an acute non-contact bowling mechanism or a gradual onset bowling mechanism. Injuries in bowlers which were sustained either when batting or fielding (including being struck by a batted ball when bowling) were not considered as part of this particular study.

The injury dataset under consideration for each match workload was those injuries occurring after the match in question for a fixed time period. Previous analysis has shown that time periods of approximately 28 days after an excessive workload should be assessed to consider whether there is an increased risk of injury related to this workload.

A player match was included in the dataset for matches played by players who regularly bowled ‘pace’ deliveries. Various analyses were then performed for each unit (player match) concerning:

1. number of match overs bowled in a given match and in time periods leading up to this match (ranging from periods covering match workloads over 5 and then 12–26 days); and
2. occurrence or non-occurrence of bowling injuries over the next month (28 days) starting from the completion of the match.

An initial period of 5 days was chosen, as this was represented a time period during which only one first class match could be played. The next period chosen for analysis was 12 days, as this allowed analysis of the minimum period in which 2 first class matches could have been played, as in the study period in Australia no first class matches for each team were scheduled within less than a week of each other. Match bowling loads were available for each match as a whole, but the bowling amounts on each day of the match were not available for analysis.

When comparing risk of future injury in high and low workload bowlers, 95% confidence intervals (CI) of Relative Risks (RR) were calculated using Taylor Series expansions to assess significance at p < 0.05 level. That is, a 95% CI which did not include 1.00 was considered significant at the p < 0.05 level. For findings close to significant, a Generalized Estimating Equations (GEE) model (SPSS 15.0) was also tested to assess the relationship between injury and number of overs bowled, testing for the repeated-measures effect of individual players.

3. Results

The relevant dataset to be considered over the time period involved exposures for 235 distinct fast bowlers over time periods
from 5 to 26 days, looking at likelihood of injury over the subsequent month (28 days). Table 1 examined the risk of injury for workload exposures over a 5 day period. This time period involved only a single first class match (or perhaps multiple limited over matches).

Table 2 details the risk of injury over the following 28 days from various workloads over a 17 day time period. We have chosen to present the 17 day results in table form as it was the time period which came closest to having a statistically-significant result. There were no statistically-significant findings at the 95% confidence level between low and high workload groups of bowlers in any of the time periods from 12 to 26 days. In particular, workloads of 51–99 overs in a short time period did not appear to confer any significant increase in subsequent injury risk compared to workloads of 50 overs or less. On raw scores, workloads of more than 100 match overs in short time periods (17 days or less) led to absolute increases in injury risk (Table 3), but the number of occasions in which 100 overs was exceeded in these short time periods was uncommon enough that statistical significance could not be reached. From Tables 2 and 3, for example, bowlers who exceeded 100 overs in a 17 day period were at approximately 80% increased risk of injury on raw score, but this did not reach statistical significance at the 95% confidence level ($p < 0.10$).

To adjust for the major confounder of the repeated-measure effect of individual players, GEE modelling was performed. Injury (in the next 28 days) was chosen as the dependent variable, number of overs bowled by the player in the past 17 days $> 100$ or $< 100$ was chosen as the model effect with player as the repeated-subject effect. The model revealed a highly significant effect (changed likelihood of injury) of individual players ($p < 0.001$). However, when the repeated-measures effect of individual players was included in the model, the risk of bowling $> 100$ overs in 17 days became less significant ($p = 0.223$).

### 4. Discussion

This study confirms the findings of a previous study that a single high fast bowling workload in cricket (50 overs in a match) leads to a significant increase in the incidence of bowling injury subsequent to the match in which the high workload occurred. The dataset used for this study overlapped with that of the previous study, with both a greater number of seasons and limited over match exposures included. Our analysis confirmed the results of the previous study that when fast bowlers in a 5 day period exceeded 50 overs, they had approximately 50% higher medium-term injury risk (14% likelihood of being injured over the following month compared to 9%). Cumulative workloads from successive matches did not seem to have a substantial effect on future injury risk. There is a relevant change in the relative injury profile between 17 day match workload (Tables 2 and 3) and a 20 day workload (Table 3) for bowlers who exceed 100 overs (also shown in Fig. 1). Within a 20 day period, exceeding 100 overs of fast bowling does not appear to any increased risk of injury. However exceeding 100 overs in a 17 day period is borderline at conferring statistically-significant increased injury risk on univariate analysis. There is an absolute risk increase of 80% but because only a small number of bowlers exceeded 100 overs in 17 days, the risk increase did not reach statistical significance at the 95% confidence level. Although in this study, only high workloads in a 5 day period conferred a statistically-significant increase, Fig. 1 and Table 3 show that in absolute terms there is a higher risk than baseline for greater than 100 overs bowled within 17 days or less. Previous study which looked at workload variations in the month subsequent to high single match workloads did not find that these variations changed the significance of the observation. Although analysis of the effects of clustering (repeated-effects measure of players) also did not find bowling $> 100$ overs in 17 days to significantly increase the risk of injury ($p < 0.223$). Despite the non-significance of the association, this may be due to an insufficient dataset and therefore it would still be prudent at this stage to recommend that bowlers aim not to exceed 100 overs in a 17 day period.

It is becoming increasingly common for teams to be scheduled to play ‘back-to-back’ matches and start a second first class match within days of the first. Although it has been a rare event in the past in Australian cricket, it is foreseeable that there will be even more regular occurrences of players being scheduled for 3 first class matches in 3 weeks, which will make it more common for bowlers to bowl 100 overs in 17 days. Further analysis can be performed to with a larger dataset to determine whether this effect becomes significant.

A conclusion from this study (that fixture compression did not appear to lead to significantly increased injury risk when first class games are spaced one week apart) does not assess whether risk would be increased if compression was even greater than this. Because only total match workloads and not daily workloads were available for analysis, we have not been able to adequately analyze maximum loads in periods from 8 to 10 days. The scenario of a team playing a back-to-back match and bowling last in the first game and first in the second game could lead to high workloads over an 8–10 day period. This may present an additional risk from back-to-back games that we have not been able to assess in this study.

There has been an absolute trend towards more cricket over the past 10 seasons in Australia, although this increase has been made up primarily by an increase in T20 cricket. Although bowlers may not be required to bowl more overs per season than their counterparts in the past, the high workload periods are compacted (and interspersed with low match workload periods during T20 tournaments).

In the T20 era, bowlers who play all forms of the game are often required to rapidly change formats with a minimal time period for adjustment. A fast bowler, for example, will bowl an average of 4
Table 2

Pace overs bowled in a 17 day period and injury risk in the following 28 days.

<table>
<thead>
<tr>
<th>Match overs bowled in 17 days</th>
<th>No. of bowlers injured in next 28 days</th>
<th>No. of bowlers not injured next 28 days</th>
<th>Risk of injury next 28 days (%)</th>
<th>Relative risk high:low workload</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>282</td>
<td>2805</td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11–20</td>
<td>224</td>
<td>2199</td>
<td>9.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21–30</td>
<td>157</td>
<td>1577</td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31–40</td>
<td>149</td>
<td>1536</td>
<td>8.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41–50</td>
<td>144</td>
<td>1252</td>
<td>10.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51–60</td>
<td>89</td>
<td>844</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61–70</td>
<td>48</td>
<td>542</td>
<td>8.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71–80</td>
<td>43</td>
<td>353</td>
<td>10.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81–90</td>
<td>21</td>
<td>209</td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>91–100</td>
<td>9</td>
<td>134</td>
<td>6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101–120</td>
<td>8</td>
<td>48</td>
<td>14.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>121–140</td>
<td>2</td>
<td>6</td>
<td>25.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>141+</td>
<td>1</td>
<td>0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–100</td>
<td>1166</td>
<td>11451</td>
<td>9.2</td>
<td>1.78</td>
<td>0.90–3.50</td>
</tr>
<tr>
<td>101+</td>
<td>10</td>
<td>55</td>
<td>15.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3

Injury risk in the following 28 days comparing days taken to bowl more than 100 match overs.

<table>
<thead>
<tr>
<th>Number of days to bowl &gt;100 match overs</th>
<th>No. of bowlers injured in next 28 days</th>
<th>No. of bowlers not injured next 28 days</th>
<th>Risk of injury next 28 days after bowling &gt;100 overs (%)</th>
<th>Relative risk (Bowling &gt;100 overs: ≤100 overs)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 days</td>
<td>3</td>
<td>15</td>
<td>16.7</td>
<td>1.96</td>
<td>0.57–6.78</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>26</td>
<td>13.3</td>
<td>1.51</td>
<td>0.52–4.32</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>32</td>
<td>15.8</td>
<td>1.84</td>
<td>0.77–4.40</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>38</td>
<td>15.6</td>
<td>1.80</td>
<td>0.80–4.05</td>
</tr>
<tr>
<td>16</td>
<td>7</td>
<td>47</td>
<td>13.0</td>
<td>1.46</td>
<td>0.66–3.23</td>
</tr>
<tr>
<td>17</td>
<td>10</td>
<td>55</td>
<td>15.4</td>
<td>1.78</td>
<td>0.90–3.50</td>
</tr>
<tr>
<td>18</td>
<td>13</td>
<td>81</td>
<td>13.8</td>
<td>1.57</td>
<td>0.87–2.83</td>
</tr>
<tr>
<td>19</td>
<td>14</td>
<td>127</td>
<td>9.9</td>
<td>1.08</td>
<td>0.62–1.88</td>
</tr>
<tr>
<td>20</td>
<td>18</td>
<td>183</td>
<td>9.0</td>
<td>0.96</td>
<td>0.59–1.57</td>
</tr>
<tr>
<td>21</td>
<td>22</td>
<td>228</td>
<td>8.8</td>
<td>0.94</td>
<td>0.61–1.47</td>
</tr>
<tr>
<td>22</td>
<td>27</td>
<td>272</td>
<td>9.0</td>
<td>0.97</td>
<td>0.65–1.45</td>
</tr>
<tr>
<td>23</td>
<td>33</td>
<td>316</td>
<td>9.5</td>
<td>1.02</td>
<td>0.71–1.47</td>
</tr>
<tr>
<td>24</td>
<td>40</td>
<td>377</td>
<td>9.6</td>
<td>1.04</td>
<td>0.74–1.45</td>
</tr>
<tr>
<td>25</td>
<td>47</td>
<td>454</td>
<td>9.4</td>
<td>1.01</td>
<td>0.75–1.38</td>
</tr>
<tr>
<td>26 days</td>
<td>57</td>
<td>611</td>
<td>8.5</td>
<td>0.91</td>
<td>0.69–1.20</td>
</tr>
</tbody>
</table>

overs per game (only) during a T20 tournament, but on resuming first class cricket may regularly be called upon to bowl 30–40 overs per game, a sudden ten-fold increase in workload. In athletics, it would be considered a grave training error for a runner to upgrade from running 10 to 100 km per week, yet this is the equivalent of the rapid workload upgrade now expected of some fast bowlers. A traditional cricket team consists of 5 specialist batsmen, 1 all-rounder, 1 wicketkeeper and 4 specialist bowlers. Of the 5 bowlers, if one is injured during a first class game, the other 4 bowlers may all be called upon to further increase their workloads by approximately 25% to make up for the bowler unavailable through injury as substitutes are not permitted. This environment makes injury more likely as it has been shown that sudden upgrades in workload are associated with increased injury risk. These findings are relevant in that it becomes harder to adequately prepare players in the fashion which is 'low risk'; that is, maintaining a constant moderate workload (not too high and not too low) to both condition but not overload. Sadly the modern schedule encourages the two extremes (unloading in T20 and overloading in first class cricket).

Fig. 1. Risk of injury as a function of overs bowled in various time periods.
5. Conclusion

Compared to sudden upgrades in workload with changing forms of the game, this paper suggests that compression of first class fixtures has a less substantive effect on fast bowler injury rates. There was no workload limit beyond which there was a statistically-significant increased risk of injury at the p<0.05 level. However it is 90% likely that bowlers who exceed 100 overs in 17 days are at an increased risk of injury. For a bowler considered at high risk of injury, it may be prudent to rest from a game within 17 days of a 100 over workload limit being reached, although this recommendation would not affect the vast majority of fast bowlers playing first class cricket.

Practical implications

- Risk of injury for fast bowlers in professional cricket is high and has increased in the years since T20 cricket became prominent.
- For the most part, higher fast bowler workloads in the medium term from repetitive first class games does not lead to a significant increase in injury risk.
- Rapid change between low workloads (T20 cricket) and high workloads (first class cricket) appears to be a greater factor in increasing fast bowler injury risk.
- It is likely that bowling 100 or more overs in 17 days leads to increased injury risk, although this threshold is not exceeded very often.

Conflicts of interest

All authors declare a potential conflict of interest due to receiving direct or indirect payments from Cricket Australia but have no other conflicts.

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