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## **Injury risk associated with ground hardness in junior cricket**

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## **Abstract**

**Objectives:** To establish if there is an association between ground hardness and injury risk in junior cricket.

**Design:** Nested case-series of players who played matches on specific grounds with objective ground hardness measures, within a prospective cohort study of junior community club cricket players.

**Method:** Monitoring of injuries and playing exposure occurred during 434 matches over the 2007/2008 playing season. Objective assessment of the hardness of 38 grounds was undertaken using a Clegg hammer at 13 sites on 19 different junior cricket grounds on the match eve across the season. Hardness readings were classified from unacceptably low (<30 g) to unacceptably high (>120 g) and two independent raters assessed the likelihood of each injury being related to ground hardness. Injuries sustained on tested grounds were related to the ground hardness measures.

**Results:** Overall, 31 match injuries were reported; 6.5% were rated as *likely to be related* to ground hardness, 16.1% as *possibly related* and 74.2% as *unlikely to be related* and 3.2% *unknown*. The two injuries *likely to be related* to ground hardness were sustained whilst diving to catch a ball resulting, in a graze/laceration from contact with hard ground. Overall, 31/38 (82%) ground assessments were rated as having 'unacceptably high' hardness and all others as 'high/normal' hardness. Only one injury occurred on an objectively tested ground.

**Conclusions:** It remains unclear if ground hardness is a contributing factor to the most common injury mechanism of being struck by the ball, and needs to be confirmed in future larger-scale studies.

**Keywords:** ground hardness, junior cricket, Clegg hammer, injury risk

## Introduction

Concerns about the possible deleterious effect of hard grounds on injury risk has become widespread in Australia and elsewhere due to changes in climatic conditions and their effect on the surface characteristics of natural turf playing fields.<sup>1,2</sup> In many sports, increasing hard ground conditions have resulted in restricted access to those grounds and, in more extreme cases, contributed to ground closure based on perceived player safety concerns.<sup>1</sup> However, there is a dearth of evidence on the link between injury risk and objectively measured ground hardness to inform and underpin this decision making, especially in sports other than the football codes.

Ground hardness has been associated with an increased injury risk primarily in football codes.<sup>3-5</sup> Harder grounds have been identified as a contributing factor to increased strain on ligaments and tendons and are therefore thought to result in a higher injury risk.<sup>6,7</sup> Whilst none of this evidence comes from cricket injury studies, there is biomechanical evidence that unpredictable ball bounces can occur from variations in grass cover on cricket pitches or impacts with hard ground.<sup>8,9</sup> It is possible, for example, that a harder ground leads to a higher vertical velocity of a cricket ball,<sup>10</sup> which could contribute to a higher injury risk associated with impacts or misfields from faster rebounding balls.<sup>7</sup> It has also been postulated that cricketers could be at risk of injury if they dive for balls whilst fielding on hard grounds.<sup>7</sup>

To date, no epidemiological studies of injuries in junior cricket have formally assessed the potential relationship with ground hardness. Studies in adult and high performance cricketers have almost exclusively focussed on injuries to fast bowlers.<sup>11,12</sup> Epidemiological studies in juniors, on the other hand have emphasised the occurrence of acute, traumatic injuries, as a result of contact with or misfielding of a cricket ball, and in a range of fielding positions.<sup>13-15</sup> A recent study found that more than half of the 284 junior cricketers' surveyed about their perception of injury risk believed there to be a high chance of injury when playing on a hard or uneven

ground, even in the absence of formal evidence to support these beliefs. In contrast, only 2% of the surveyed junior players reported a high chance of injury when playing on a well covered grass field.<sup>16</sup>

A limitation of much sport ground hardness research to date is that evidence linking it to injury is primarily observational in nature, derived from statistical associations of injury rates with weather variables,<sup>4, 17, 18</sup> rather than based on well-designed aetiological studies incorporating direct measurement of ground hardness. This has led to inconsistent findings, ranging from a reported increase in fractures on harder grounds<sup>19</sup> to a non-significant association between hardness and injury incidence.<sup>5</sup> There is a clear need for appropriately designed aetiological studies that incorporate objective measures of ground hardness to more confidently define the importance of ground conditions in determining sport-specific injury risk on natural turf across a range of sports, including cricket.<sup>20</sup>

The aim of this study was therefore to establish if an association exists between ground hardness and injury risk in junior community level cricket through prospective monitoring of injuries over one full playing season and objective measurement of ground hardness on a subset of fields where some matches were played. In doing so, it examined the nature, body region and mechanism of the injuries.

## **Methods**

This study was part of the Juniors Enjoying Cricket Safely (JECS) prospective cohort study and the full injury surveillance and exposure methods are described in detail elsewhere.<sup>15</sup> This nested case-series study monitored all injuries in 203 under 14 years (U14) and 120 under 16 years (U16) players during 434 matches from teams/clubs from a regional junior cricket association, in Victoria Australia, over the 2007/08 playing season. This corresponded to over 1300 hours of accumulated

match play. Injuries and all participation episodes when batting, bowling or fielding in the 434 matches were recorded using primary data collectors (PDCs) and standardised participation and injury incident report forms.<sup>15</sup> Injury was defined as “an event which requires the provision of medical attention, either on or off the field, and/or results in missed participation during the match”. Ethics approval was granted by the University of Ballarat Human Research Ethics Committee and written consent was obtained from all participants.

Based on the reported injury surveillance data, which included a narrative description of each injury event, two independent raters with expertise in biomechanics and hence knowledge in both injury mechanisms and player surface interactions assessed the likelihood of each injury being related to ground hardness to create a Ground Hardness Injury Risk (GHIR). The following four categories were used: *unlikely to be related*, *possibly related*, *likely to be related* and *unknown* (due to insufficient details). When there was disagreement (6.5%), an additional rater was consulted and a majority consensus categorisation was accepted.

Direct measures of ground hardness were recorded on a purposively-selected sample of the community grounds where the junior cricket matches were played weekly over the 18-week 2007/08 season. It was not possible to test every ground every week due to the varying physical locations of the grounds across all teams. Priority was given to grounds where two JECS project teams were scheduled to play each other. All U14 and U16 teams had their match grounds tested between 1-4 times during the season. On average, three grounds were tested each week and testing took place on the grounds the day before a scheduled match to avoid disruption to the game day schedules. Data was excluded where there was change in ground conditions due to rainfall between testing and the match. For logistic reasons associated with the timing of the testing sessions, 38 test sessions were conducted on 19 grounds (Supplementary File 1). No hardness data were collected

in weeks 10–12 due to rain on the day of testing. All tested grounds had a centrally-located synthetic wicket area and a natural turf outfield.

Ground hardness was measured at 13 sites on each ground according to the widely used Australian football ground hardness test protocol.<sup>21</sup> This protocol was chosen because it is commonly adopted as standard practice by grounds managers across Australia and cricket is generally played on the same fields as Australian football. Six of the nine test sites previously used in football studies were adopted as they also related to cricket match fielding positions. These were supplemented with seven additional test sites relevant to other cricket playing positions (Figure 1; Table 1).

<Insert Figure 1, Table 1 about here>

Ground hardness was measured by one of the authors (PW) using a Clegg hammer which consisted of a 2.25 kg hammer fitted with an accelerometer. This was released from a height of 45 cm through a guide tube and deceleration on impact was recorded in gravities (g). Consistent with the procedure adopted in previous studies,<sup>19</sup> four single drops were recorded within each of the 13 one metre square test locations (total of 52 readings) on every ground to assess condition consistency at each test site.

Data were recorded on a standardised ground condition testing sheet (Supplementary File 2). The first Clegg hammer drops within the square metre were averaged to obtain the site-specific ground hardness measure. For ease of interpretation, and in the absence of any cricket-specific reference ranges, the data were categorised according to the following ratings widely used for Australian football grounds<sup>21</sup>, where 'unacceptably hard' represents measures >120g, 'high/normal' 90–120g, 'preferred range' 70–89g, 'low/normal' 30–69 and 'unacceptably soft' <30g. The average of the ground hardness measures, across all sites, was taken as the final ground hardness assessment for each tested ground. The ground hardness

measures were then linked to injury reports and player exposure data corresponding to matches played on the following day. It was not possible to assess the relationship between injuries and grounds not objectively tested, because of the absence of ground hardness measures for the latter.

Data was double entered into Microsoft Excel and cleaned and edited before being transferred into SPSS Version 17 for analysis. Descriptive statistics and frequency distributions were calculated within the five categories of objectively measured ground hardness and the four GHIR categories. These were also assessed across injury characteristics: body region, nature and mechanism of injury.

## **Results**

Over the entire playing season and all players, a total of 31 injuries was recorded corresponding to an injury rate of 3.49 injuries per 1000 match exposures (95%CI: 2.26-4.72). Of these, 2 (6.5%) were independently rated as *likely to be related* to ground hardness, 5 (16.1%) as *possibly related* and 23 (74.2%) as *unlikely to be related*. There was insufficient detail on one injury to accurately rate the likelihood and therefore it was classified as *unknown*. The nature, body region and cause of injury related to GHIR are presented in Table 2. Both injuries that were *likely to be related* to the ground hardness were sustained when the player was diving to catch the ball and grazed or cut their skin from contact with the hard ground. A high proportion (60%) of the injuries classified as *possibly related* to ground hardness were bruises/inflammation sustained by the players being struck by the ball bouncing off the ground.

<Insert Table 2 about here>



Across the 38 objective ground assessments of selected grounds, the median (range) for the Clegg hammer was 144 g (69–313 g) and when ground hardness was rated according to the widely adopted Australian football scale,<sup>21</sup> 31/38 (82%) average ground assessments were rated as having ‘unacceptably high’ hardness and all others as ‘high/normal’ hardness.

Only one of the reported injuries occurred on one of the grounds that underwent objective testing on the match eve. No injuries were reported during matches played following the other 37 ground assessments. Unfortunately, this meant that no statistical analysis of injury risk in relation to ground conditions was possible.

Nonetheless, a qualitative description of that injury is presented here. This particular injury was the most serious injury recorded in the whole cohort, and was the only one that required a player to be taken to hospital. The player was struck in the face by a ball while fielding and suffered bruising, inflammation and concussion. The PDC described the incident as “X was fielding at mid wicket, ball reeled off grass, hitting him in the face.” The PDC from the opposing team commented to a member of the research team on the day of the injury: “This is the worst field I have ever seen.” It occurred on a ground that was rated as having “unacceptably high” hardness. The GHIR for this injury was rated as *possibly related* to ground hardness because it was not obvious that the injury occurred because the ground was hard. Importantly, no injury was reported during matches for 30 of the 38 grounds objectively rated on the previous day as having “unacceptably high” hardness.

## **Discussion**

This is the first study to describe injuries in junior cricket in relation to ground hardness, both in terms of a subjective assessment of the link between the two and an objective measure of ground hardness on cricket fields during a playing season.

The overall match injury rate was low (3.49 injuries per 1000 match exposures), which is lower than injury than that in more senior forms of the game as reported for the full cohort study.<sup>15</sup> Of the 31 injuries, fewer than a quarter were judged as being possibly or likely related to ground conditions. Only one injury occurred on any of the objectively measured grounds and could be compared to a formal ground hardness assessment.

It has been argued that in cricket, harder grounds have been associated with a higher ball velocity<sup>10</sup> and a decrease in the softness of the landing surface.<sup>7</sup> As such, hard grounds may increase the risk of superficial injuries such as bruising and lacerations caused by players being struck by the ball or diving to field the ball.<sup>7</sup> It has also been suggested that hard grounds may increase the strain on muscles, ligaments and tendons.<sup>6</sup> While there were incidents of both of these injury types recorded in the current study, the overall injury rate was low. This coupled with only one injury occurring on a ground that was objectively tested the day before, made it impossible to detect a direct link between ground hardness and the frequency or type of injuries sustained by junior cricket players. However, objective measures of ground hardness and detailed descriptions of injury events made it possible to interpret the injuries in light of the overall “unacceptably high” hardness of the grounds

There were five incidents of a player being struck by a ball while fielding, whereby the ball bounced off the ground and connected with the player causing bruising or inflammation at the site of contact. This was the most common type of injury sustained by fielders and it is possible that the higher ball velocity created by the hard ground was a contributing factor. However, it is also possible that these injuries were caused by unanticipated ball deflections created by uneven surfaces, for example tufts of grass in otherwise bare areas. Ten (91%) of the batting injuries were also caused by a player being struck by the ball. The cricket pitches were all synthetic with a concrete base, making them a consistent, but very hard surface. Ball

velocity, but not uneven surface, may have contributed to these injuries. There were similar numbers of batting, fielding and bowling injuries in this cohort,<sup>15</sup> which has not been demonstrated in studies conducted with adults, for whom overuse injuries are much more common, or prior to the drought conditions.<sup>22</sup> This suggests that faster ball speeds due to harder grounds may be causing problems for junior fielders similar to those experienced by junior batters who perhaps do not have the reaction speed of their adult counterparts. Nevertheless, since the junior cricket players themselves perceived a high risk of injury when playing on uneven grounds<sup>16</sup> (as distinct from hard grounds), ground evenness would be useful additional surface information to collect in future studies.

There were two incidents where a player sustained skin damage when diving to the ground to field the ball. While it is acknowledged that the severity of these injuries was minor, they were nonetheless a direct result of the hard ground and in one case resulted in the player leaving the field to receive treatment. The fact that there were not more of this type of injury suggests that some players may have modified their behaviour in response to their reported perceptions of high injury risk associated with playing on hard and uneven grounds.<sup>16</sup> A number of studies have demonstrated that children are more likely to take risks if they appraise danger as low, or judge their personal vulnerability for injury to be low.<sup>23</sup>

The increased strain on ligaments and tendons previously associated with hard grounds<sup>6</sup> was not observed in the current study. The majority (67%) of the sprains/strains sustained by the junior players occurred while batting and in the delivery phase of bowling, and were caused by overexertion and errors in technique rather than hard grounds. In addition to the differences in biological tissue associated with this age group, the physical demands (e.g., distance covered) placed on junior fielders compared to their adult counterparts may have contributed to this finding.

The use of Global Positioning Systems (GPS) in future studies could provide valuable insights into the demands of the game.

Whilst the ability to determine the relationship between ground hardness and injury risk is limited by the fact that only one injury occurred on the grounds tested, it is also notable that no injuries occurred on the other 37 grounds assessed. The hardness values ranged from 67–313 g on these 37 assessments, suggesting that hard ground may not be as dangerous for junior cricketers as the players perceive it to be<sup>16</sup> or as the Australian football protocol rating categories indicate for this sport.

With limited resources and the time demands on testing and travelling between grounds, it was not possible to test all grounds every week. Direct ground assessments on every ground before every match would be ideal but is somewhat unrealistic in community level sport due to limited resources and the wide geographical regions included in many community level competitions. It is apparent from this study that further evidence is needed on the relationship between hard grounds and injury in cricket, therefore, the challenge of future research is to maximise the number of ground assessments undertaken. There was no formal power analysis undertaken due to the lack of injury rates for community level junior cricket players, however, given the low number of injuries found in this cohort future studies would need to be larger to accurately determine the association. Furthermore, this study focussed on junior cricket only and as the evidence purports differences in the types of injuries sustained in the adult form of the game,<sup>15</sup> it is not possible to generalise these results across all cricket players. Future studies need to be undertaken to determine the relationship between hard and/or uneven grounds and injury risk in adult cricket.

## **Conclusion**

To date, there has been no study published in the peer-reviewed literature linking cricket injuries specifically to ground hardness but cricket associations are still having to make decisions about ground hardness and possible closure in the absence of such evidence. This study shows that the likely risk of injury on grounds rated as having ground hardness measures above 120 g is not as high as it would be for injuries in Australian football on those same grounds. It is possible that the observed low injury rates result from changes in player behaviour (i.e. risk compensation such as what might occur if players do not throw themselves after a ball to catch it if they perceive the ground to be too hard to land on). Alternatively, they might reflect the true level of injury risk in junior cricket, in that harder grounds are needed to play cricket. The contribution of ground hardness to the most common injury mechanism of being struck by the ball, remain somewhat unclear and uneven grounds may be of an equal concern and need to be considered in future research.

## **Practical Implications**

- Objective ground hardness measures are critical for accurate interpretation of the association with injury.
- Hard grounds may not be as dangerous for junior cricket players as the players perceive them to be.

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Table 1 Description of the 13 ground hardness test sites in relation to common cricket player positions

Site Number	Site Description	Player Position
1	In front of stumps, at end B	Batter (striker)
2	Halfway down pitch towards side C/D	Batter (run alongside pitch)
3	In front of stumps, at end A	Batter (non-striker)
4	5m directly behind stumps at end B	Wicket keeper (alternate overs)
5	10m behind bowling crease, in line with the midpoint between the stumps and the return crease on side D	Bowler (alternate overs)
6	5m diagonally out from corner of the pitch on side C, end B	Fielder (slips/gully)
7	10m from edge of pitch, halfway down pitch on side C	Fielder (cover)
8	5m directly behind stumps at end A	Wicket keeper (alternate overs)
9	10m behind bowling crease, in line with the midpoint between the stumps and the return crease on side C	Bowler (alternate overs)
10	5m diagonally out from corner of	Fielder (mid-on)

	the pitch on side D, end A	
<b>11</b>	10m from edge of pitch, halfway down pitch on side D	Fielder (midwicket)
<b>12</b>	5m in from boundary in line with middle of pitch on side D	Fielder (deep midwicket)
<b>13</b>	5m in from boundary at end A, towards side C	Fielder (long-off)

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Notes: 1. Drawings of the position of end A and B and side C and D relative to the position of the ground were recorded to ensure that sites A/B and C/D were the same each time a particular ground was tested.

2. Site descriptions and player positions are described for a right-handed batsman standing in front of the stumps at end B facing a right arm over the wicket bowler.

Table 2 The number of injuries (with the percentage in brackets) in each of the four levels of likelihood to be related to ground hardness for body region, nature and injury mechanism (n=31 match injuries sustained during U14 and U16 community club cricket).

	Likely to be related	Possibly related	Unlikely to be related	Unknown	Total
<b>Body region</b>					
Head/neck/face	0	2(40)	3(60)	0	<b>5(100)</b>
Upper limbs	1(11)	1(11)	6(67)	1(11)	<b>9(100)</b>
Torso/back	0	0	5(100)	0	<b>5(100)</b>
Lower limbs	1(8)	2(17)	9(75)	0	<b>12(100)</b>
<b>Nature</b>					
Strain	0	0	4(100)	0	<b>4(100)</b>
Sprain	0	0	1(50)	1(50)	<b>2(100)</b>
Cut/laceration	1(33)	0	2(67)	0	<b>3(100)</b>
Abrasion/graze	1(50)	1(50)	0	0	<b>2(100)</b>
Bruise	0	2(16.7)	10(83.3)	0	<b>12(100)</b>
Inflammation/swelling	0	1(20)	4(80)	0	<b>5(100)</b>
Concussion	0	1(100)	0	0	<b>1(100)</b>
Overuse/ongoing	0	0	1(100)	0	<b>1(100)</b>
Other	0	0	1(100)	0	<b>1(100)</b>
<b>Cause</b>					
Struck by ball	0	3(15)	16(80)	1(5)	<b>20(100)</b>
Mishandling ball while fielding	0	1(100)	0	0	<b>1(100)</b>
Dive for catch	2(100)	0	0	0	<b>2(100)</b>
Overexertion	0	0	3(100)	0	<b>3(100)</b>
Slip/trip	0	1(50)	1(50)	0	<b>2(100)</b>
Twisting to change direction	0	0	1(100)	0	<b>1(100)</b>
Overuse/gradual onset	0	0	2(100)	0	<b>2(100)</b>