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Original research

Incidence and impact of time loss and non-time-loss shoulder injury in elite South African cricketers: A one-season, prospective cohort study

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ABSTRACT

Objectives: To determine the incidence, prevalence and impact of shoulder injury in elite South African cricketers.
Design: Prospective longitudinal cohort study.
Methods: One hundred and six senior national/franchise cricketers completed a pre-season Kerlan-Jobe Orthopaedic Clinic shoulder and elbow (KJOC) score. All injuries sustained during the 2016/2017 season were captured on an injury reporting system. Injuries were verified by the respective squad physiotherapist at the end of the season and post-season KJOC score was obtained from all the players.
Results: Eighteen percent (95% CI: 11–25%) of cricketers sustained a shoulder injury, at a rate of 0.19 injuries per player per year. Annual injury prevalence was 1.1%. Shoulder injury occurred primarily while throwing (58%). Fielding performance was maintained by adapting throwing technique (58%) or fielding position (21%). Thirty-two percent of shoulder injuries resulted in time lost to matches and/or training. A history of shoulder injury increased the risk of sustaining another injury by 1.91 times (95% CI: 1.73–2.15). Irrespective of injury, cricketers demonstrated consistently low pre- (78.5 ± 15.6) and post-season (81.2 ± 17.1) KJOC scores. Pre-season KJOC scores were significantly lower ($r^2 = 0.106$, $p = 0.001$) in those cricketers with a history of shoulder injury. Cricketers who sustained a seasonal shoulder injury had significantly lower ($r^2 = 0.112$, $p < 0.001$) post-season KJOC scores, indicating persistent shoulder pain or dysfunction.
Conclusion: This is the first study to report both time- and non-time-loss shoulder injury in elite South African cricketers. All non-time-loss shoulder injuries compromised primary skill, while some resulted in changes to throwing technique and fielding position. Thus shoulder injury, whether it results in time loss or not, potentially impacts match performance.

Practical implications

- When combining both time-loss and non-time-loss injuries, 18% of elite South African cricketers sustained a shoulder injury in the 2016/2017 season.
- The incidence of non-time-loss shoulder injury in elite South African cricketers is 13%.
- Non-time-loss injuries impacted primary skill in 100% of cricketers with shoulder injury, while 80% also reported a negative impact on fielding performance.
- A baseline measure of shoulder function should be determined at pre-season, repeated monthly during the season and/or at the time of injury.

1. Introduction

Shoulder injuries have previously been reported to account for 5–7% of all injuries amongst elite cricketers.[2–4] These injury surveillance studies defined an injury as, a musculoskeletal condition that prevented a player from being selected for match participation or inhibited a player from further participation in a match.[5] The

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use of this "match time-loss" definition may overlook 70–92% of injuries.[6] In fact 69–85% of cricketers with shoulder pain/injury are able to continue training and match play, by fielding in a different position.[7–9]

Since the "match-time-loss" injury definition is not suitable for shoulder injuries, recent injury surveillance studies in cricket have either adapted the definition of shoulder injury/pain used in self-report questionnaires,[7,8] or used a battery of shoulder questionnaires to assess function (Kerlan-Jobe Orthopaedic Clinical shoulder and elbow (KJOC) score) and instability (Melbourne Instability Shoulder Score and the Western Ontario Shoulder Instability Index).[9] With the use of this alternate approach (i.e.: inclusion of non-time-loss in the definition of injury), shoulder injuries have been found to account for between 15% and 36% of all injuries in elite junior Australian and English cricketers, respectively; and 23–36% of all injuries in elite senior English cricketers.[7–9]

The most common shoulder injury reported in literature for cricketers, pertain to the rotator cuff musculature and/or tendons[1,4,10] and is thought to be associated with an impingement mechanism.[7,12,13] Overhead throwing when fielding is considered the most provocative activity associated with shoulder injury in cricketers.[7,12,13] Bowlers have a tendency to be positioned in the outfield during matches and are thus required to throw over large distances placing greater force on the shoulder joint, increasing their susceptibility to shoulder injury.[7,9,14] Other factors which are known to contribute to the development of cricket related shoulder injuries include time of season (early season, due to lack of conditioning; and end of the season, due to fatigue),[1,15] shorter formats of the game (T20 > ODI > Test),[16] progression of level of play and competition (elite > amateur > youth > junior)[16] and history of previous shoulder injury.[1,8]

The investigation of non-time loss shoulder injuries in cricketers is essential to determine the effect on performance and associated development of musculoskeletal imbalances which may alter movement sequencing patterns, potentially resulting in more serious "time-loss injuries". Therefore, the aim of this study was to determine the incidence and prevalence of all shoulder injuries in elite South African cricketers irrespective of time lost to match and training participation. In addition, general shoulder function was evaluated as part of a continuum from normal shoulder function to time-loss injury.

2. Methods

All male cricketers representing a South African franchise or senior national team underwent an annual pre-season musculoskeletal screening. For the 2016/2017 season, all players were invited to participate in this study. Four players were unavailable to participate in the study as they were currently playing abroad. A further 19 players were also unavailable as they came from a franchise whose medical management were unavailable to coordinate testing. The study was approved by the Human Research Ethics Committee, University of Cape Town (HREC: 364/2016). All participants provided written informed consent prior to the commencement of the study.

Participants completed a questionnaire to obtain demographic data; training, competition and injury history, as well as the KJOC score prior to the commencement of their annual pre-season musculoskeletal screening. Training data included the weekly frequency and number of hours spent performing the cricket disciplines of batting, bowling and fielding; as well as performing cardiovascular fitness and strength based exercises. Competition data was obtained by players indicating selection availability per match format (i.e. multiple-day, one-day or T20 matches) based on the season fixtures. Injury history included all injuries sustained by the player over the last 5 years. This information was entered into a database at the original time of injury by the team medical staff (physician or physiotherapist) and subsequently extracted for the purposes of this study.

Lastly, the KJOC score is a shoulder function questionnaire, specific to overhead athletes.[17] It comprises 10 questions, divided into three sections that include function and athletic performance, symptoms related to the upper limb and interpersonal relationships related to performance, to create a total of 100-points. Each question is measured using a 10 cm visual analogue scale, where 0 = lowest level of function/performance and greatest severity of the symptom assessed and 10 = highest level of function/performance and lowest possible severity of symptom assessed. A score <90% indicates the absence of full shoulder function[18] and is thus considered to be clinically relevant. Alberta et al.[17] found the KJOC Score to be both a reliable (ICC = 0.88) and valid (r = 0.84–0.86) measure of shoulder and elbow function in intercollegiate and professional overhead athletes.

Completion of these two questionnaires (demographics and KJOC) occurred over a two-week period in September, which is the start of the domestic cricket season. As the National team play all year round and do not have a specific pre-season, testing was conducted at a training camp which coincided with the start of the domestic season. The National and franchise cricketers were then followed for a period of six months, from October to March, which constituted the 2016/2017 domestic cricket season, and all injury data were collected for this period.

Shoulder function was selected to determine the required sample size,9 as functional ability is the primary outcome measure of this study. The smallest meaningful difference (SMD) and minimal detectable change (MDC) for the KJOC score have yet to be determined. However, the KJOC score was validated against the DASH questionnaire[17] which has an SMD of 16.3 and MDC of 12.4.[19] These values were thought appropriate to determine the required sample size for shoulder function. With statistical significance accepted as $p < 0.05$, 18 participants will provide 80% statistical power for shoulder function. Note the national squad of 15 cricketers yields 67% statistical power for shoulder function.

All injuries sustained by participants in the 2016/2017 cricket season were recorded prospectively by the respective squad medical personnel (medical doctors or physiotherapist) and loaded onto an online injury reporting system. For the purposes of this study, shoulder injury was defined as a "medical attention" injury as proposed in the updated international consensus statement on injury surveillance in cricket by Orchard et al.[20] Therefore, any shoulder-related condition sustained during competition and/or training that required medical attention, irrespective of time lost to training and/or competition was noted as a shoulder injury. In addition, clinical diagnosis of injuries followed the International Statistical Classification of Disease and Related Health Problems (ICD) list, produced by the World Health Organisation (WHO).[21] Note that where a cricketer sustains an identical injury to the same musculoskeletal structure, without further/different pathology, during the period of surveillance in this study, shoulder "injury recurrence" rather than a new injury, is recorded. All injury data was corroborated at the conclusion of the 2016/2017 cricket season with each respective squad physiotherapist. No changes to the recorded electronic data were required. All participants repeated the KJOC score at the end of the season.

Shoulder injury incidence and prevalence for the 2016/2017 South African Cricket season was calculated using the guidelines recommended by Orchard et al.,[20] which considers a standard squad as 100 players and a cricket season as 365 calendar days. Annual injury incidence was determined as: *total injuries* × *(standard squad size* × *standard cricket season)/(actual squad size* × *number of match days)*. Match injury incidence was

determined as: *1000 × (total injuries/total match days)*. Annual injury incidence was reported in the unit of injury per player per year, while match incidence was reported as number of injuries per 1000 player hours.

Annual injury prevalence was determined as: 100 × (total missed cricket days)/(actual squad size × standard cricket season). Match prevalence was determined as: 100 × (number of missed cricket matches)/(total number of matches × actual squad size). Both annual and match prevalence were expressed as a percentage.

Orchard et al.[20] describe annual injury prevalence as: *"The percentage of players unavailable on the basis of general time-loss status taking into account daily status over 365 days"*. However, match injury prevalence is regarded as the percentage of players unavailable for match participation because of injury and may be calculated according to different cricket match formats (test, one day and T20) or a combination thereof.[20]

Relative risk (RR), confidence intervals (95% CI) and standard error of measurement (SEM) of injury incidence were assessed using the equations proposed by Knowles et al.[22] All cricket squads were analysed and a comparison between the national squad and franchise squads (provincial teams) was assessed, as level of participation is known to influence shoulder injury risk.[16]

Descriptive variables and the pre- and post-season KJOC scores were analysed using Statistica version 13.3. All variables were screened for normality using the Shapiro Wilk Test. As data were not normally distributed with equal variance, a Mann–Whitney U test was used to determine potential group differences for both injury history and injury sustained in the 2016/2017 season.

Lastly, the RR for the categorical variable of previous shoulder injury was calculated using the equation recommended by Bahr and Holme.[23] Relative risk was determined as: *(Uninjured in season, with history of previous injury/Injured in season, with history of previous injury)/(Uninjured in season, with no history of previous injury/Injured in season with, no history of previous injury*. Statistical significance as accepted at $p < 0.05$. Data are presented as mean ± standard deviation.

3. Results

Eighty-two percent of elite senior male South African cricketers (106 of 129 cricketers) volunteered to participate in, and completed this study, with a mean age of 26.6 ± 4.2 years (Table 1). The cricketing cohort consisted of 17 (16.04%) left and 89 (83.96%) right handed players from all cricket disciplines. A total of 19 cricketers sustained a shoulder injury during the 2016/2017 season (National squad = 5; franchise squads = 14). Eighteen non-traumatic injuries occurred to the dominant shoulder and one traumatic injury to the non-dominant shoulder. The latter was sustained by a franchise cricketer when diving and landing on the shoulder to field a ball during training, and resulted in a loss of one match day only.

Of the entire cricketing cohort a total of 34 cricketers had a history of previous shoulder injury (National squad = 6; franchise squads = 28). Of those cricketers who sustained a shoulder injury during the 2016/2017 season, nearly half (47%; 9/19) had a history of previous shoulder injury. Eight of these cricketers sustained 5 new injuries and 3 recurrent injuries to the same shoulder previously injured; while a single new traumatic injury occurred to the opposite shoulder. The risk of sustaining a shoulder injury in a cricketer is 1.91 (95% CI: 1.73–2.15) times greater with a history of previous shoulder injury. This relative risk ratio for previous injury is higher for the national squad (RR = 2.25; 95% CI: 1.88–2.62), compared to the franchise squads (RR = 1.90; 95% CI: 1.71–2.14).

A detailed description of injury incidence, prevalence and the variables associated with shoulder injury in the season, are presented in Table 1 and 2 respectively. Eighteen percent (95% CI:

Table 1
The descriptive variables of participants used in this study and a summary of shoulder injury incidence and prevalence, according to squad representation.

Squad	All (n = 106)	National (n = 15)	Franchise (n = 91)
Age (years)	26.6 ± 4.2	28.9 ± 3.7	26.3 ± 4.2
Dominance (left/right)	17/89	2/13	15/76
Speciality (n)			
Fast bowler	51	7	44[a]
Spin bowler	26	3	23
Bat	29	5	24
Previous history of shoulder injury (yes/no)	34/72	6/9	28/63[a]
Shoulder injury sustained in 2016/2017 season (yes/no)	19/87	5/10	14/77[a]
Match incidence			
5-day	n/a	4.1	–
4 day	n/a	–	0.4
One Day	1.0	–	1.3
T20	1.1	–	1.1
All matches	0.9	2.6	0.6
Annual incidence	0.19	3.04	0.18
Match prevalence			
5-day	0.02	10.7	–
4 day		–	0.63
One Day	0.2	6.7	0.06[a]
T20	0.1	6.7	0.0
All matches	0.2	10.8	0.03
Annual prevalence	1.1	7.1	0.1

[a] One participant sustained a traumatic shoulder injury to the non-dominant side.

Table 2
The descriptive variables of shoulder injuries sustained during the 2016/2017 season according to team representation.

Squad	All (n = 19)	National (n = 5)	Franchise (n = 14)[a]
Speciality			
Fast bowler	8	3	5[b]
Spin bowler	4	–	4
Batsmen (incl. WK)	7	2	5
Occurrence of injury			
Practice	8	1	7[b]
Domestic matches			
T20	1	–	1
ODI	3	–	3
4-Day test	3	–	3
International matches			
T20	–	–	–
ODI	–	–	–
5-day (test)	4	4	–
Activity associated with injury occurrence			
Bowling	4	2	2
Batting	1	–	1
Field – throw	11	2	9
Fielding – catch	–	–	–
Fielding – dive	3	1	2[b]
Performance negatively affected by injury			
Speciality	13	5	8[b]
Throwing action	11	3	8
Field placement	4	3	1
Selection	6	2	4[b]
Type of injury[c]			
Muscle strain	6	3	3
Labral tear	1	–	1[b]
Fracture	1	1	–
Tendinopathy	10	1	9
Capsular sprain	1	–	1

[a] One squad included in the franchise cohort did not sustain any shoulder injuries during the 2016/2017 season.
[b] Non-dominant shoulder injury to one participant.
[c] Injured players were followed up with special investigations including x-ray, MRI or musculoskeletal ultrasound.

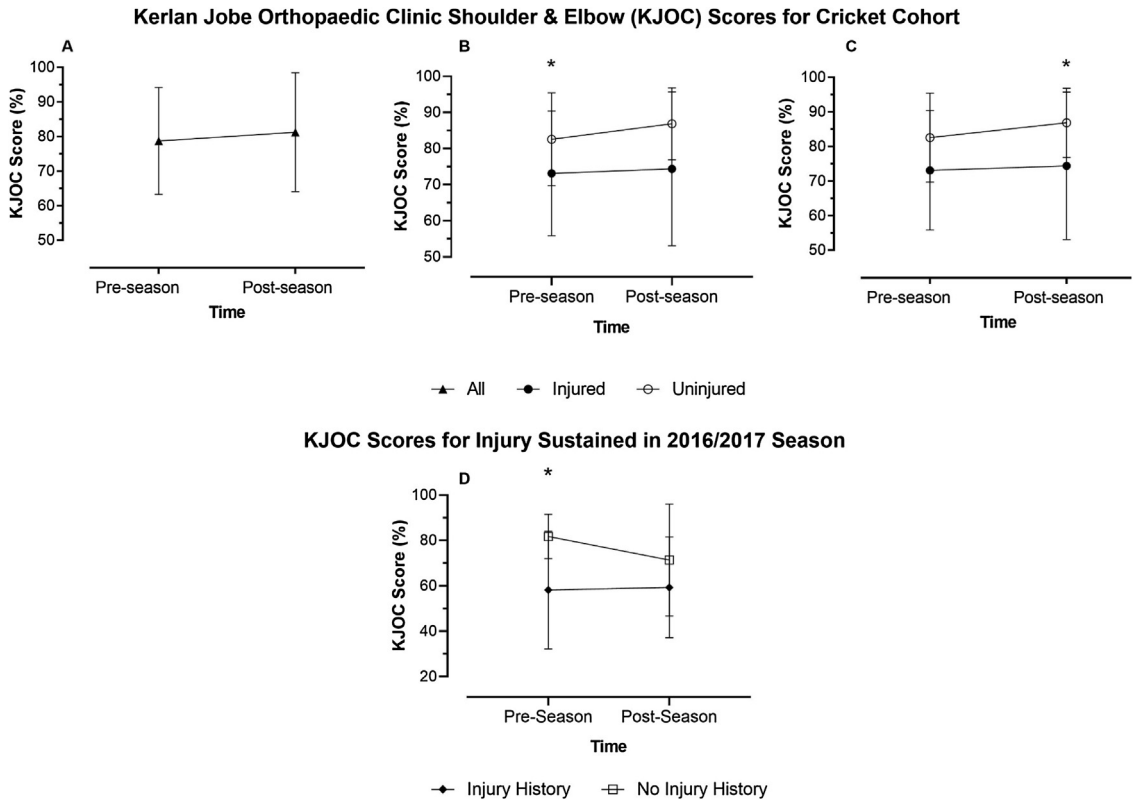

Fig. 1. A. Group KJOC scores over the 2016/2017 season (n = 106). B. KJOC Scores over the 2016/2017 season between cricketers with a history of shoulder injury (n = 34) and without (n = 72). C. KJOC Scores between cricketers that sustained a shoulder injury in the 2016/2017 season (n = 19) and those who did not (n = 87). D. KJOC Scores for shoulder injury sustained in 2016/2017 season (n = 19) with a history of previous shoulder injury (n = 9) and without (n = 10) *group difference ($p < 0.03$).

11–25%) of elite South African cricketers sustained a shoulder injury in the 2016/2017 season, at a rate of 0.19 shoulder injuries per player per year. The national players were no more likely to sustain an injury than the franchise players (RR = 1.27; 95% CI: 0.34–1.34).

Eleven injuries occurred during matches, while eight occurred during cricket specific training. Most injuries (58%) were sustained while throwing, with these occurring during fielding. A clinical diagnosis of rotator cuff muscle tendinopathy (55%) and/or strain (33%) was most frequently reported.

Thirty-two percent of cricketers who sustained a shoulder injury were unavailable for match selection. These match time-loss injuries caused approximately 21 ± 24 (range of 5–50) and 2 ± 1.5 (range of 1–4) days of missed cricket in the national and franchise squads, respectively. Sixty eight percent of cricketers who sustained a shoulder injury were able to continue with training and match participation. One hundred percent of non-time-loss injuries impacted primary skill (i.e.: bowling, batting) while 80% impacted fielding. Of the injuries that impacted fielding, 58% caused changes to throwing technique and 21% to fielding position.

The National squad demonstrated the highest shoulder match injury incidence during the five-day tests (4.1 shoulder injuries per 1000 player hours). Conversely, the highest shoulder match injury incidence for the franchise squads was found in one day (1.3 shoulder injuries per 1000 player hours) and T20 (1.1 shoulder injuries per 1000 player hours) formats, respectively.

Fig. 1 summaries the pre- and post-season KJOC scores according to group mean, injury history and injury sustained in the 2016/2017 season. Overall, this cohort of cricketers (n = 106) demonstrated low mea-198n pre- ($78.5 \pm 15.6\%$) and post-season (81.2 ± 17.1) KJOC scores (Fig. 1A). The pre-season KJOC score was significantly lower ($r^2 = 0.106$, $p = 0.001$) for cricketers who had sustained a previous shoulder injury (n = 34), compared to those with no history of previous injury (n = 72), (Fig. 1B). Similarly, the post-season KJOC Scores were significantly lower ($r^2 = 0.112$, $p < 0.001$) for cricketers who sustained a shoulder injury in the 2016/2017 season (n = 19), compared to those with healthy shoulders (n = 87), (Fig. 1C).

Finally, cricketers who sustained a shoulder injury in the 2016/2017 season (n = 19) and had a history of previous shoulder injury (n = 9) demonstrated significantly lower pre-season KJOC scores ($r^2 = 0.044$, $p = 0.03$), compared to those with no history of previous injury (n = 10), (Fig. 1D).

4. Discussion

Shoulder injuries in elite South African cricketers were reported by 18% of players over the 2016/2017 season. While this result is in agreement with the 15–36% previously reported in recent injury surveillance studies conducted on elite junior Australian,[9] as well as junior[8] and professional county[7] English cricketers; it is higher than the 5% originally reported for South African cricketers.[1] The disparity in number of shoulder injuries reported in this cohort compared with other studies can be attributed to the fact that only time-loss shoulder injuries were reported in the previous study.[1] Had this description been used in the current study, an injury incidence of 5% would have been found, as only 32% (6 of 19 shoulder injuries) of shoulder injuries sustained by elite South African cricketers during the 2016/2017 season, resulted in time-lost to match participation.

Throwing has been identified in the literature as the primary activity associated with shoulder injury[1,4,10] and the rotator cuff tendons as the structures most frequently injured.[1,4,10] These findings are supported by this study. Notably, the most frequent shoulder injuries in this study were tendinopathies (55%; 10/18 non-traumatic injuries) followed by muscle strains (33%; 6/18 non-traumatic injuries). The impact of shoulder injury on the performance of specific skills, such as batting and bowling, was found

to be similar to the 46–67% reported in current literature.[7,8] Conversely the impact of shoulder injury on fielding position, was substantially lower than the 58–60% noted in previous studies.[7,8] Only 21% of elite South African cricketers with a shoulder injury, indicated that fielding position was altered, whereas 58% indicated throwing technique was altered. It is plausible that the adjustment to throwing technique allowed injured cricketers to field in their usual positions.

The impact of changes in fielding position or throwing technique on performance during a match could not be evaluated in this study, but does raise concerns about throwing performance, particularly in the T20 format of the game which is shorter, more explosive and may require greater throwing frequency and intensity.

In this investigation, consistent with studies involving baseball players,[17,24] the KJOC score effectively distinguished between cricketers playing with pain, without pain or not playing at all due to pain. Thus, it is suggested that future injury surveillance studies include a measure of functional impediment in association with pain, in the definition of injury.

Substantially lower pre-season KJOC scores were achieved when compared to the normative value of 90%, recommended by Kraeutler et al.[18] for baseball players. This finding indicates that despite the lack of reported shoulder injury, a number of cricketers did not report 100% shoulder functional ability. Not only is this sub-optimal shoulder function correlated with an increased risk of injury, but it can potentially impact performance. This emphasises the necessity to investigate the musculoskeletal profile of a cricketer's shoulder, throwing kinematics, as well as the potential effect of these respective variables on shoulder injury risk.

Eight shoulder injuries occurred during training, while 11 occurred during matches. The slightly higher number of shoulder injuries sustained during matches, could be associated with throwing intensity. A match situation (limiting the number of runs scored by the opposition or effecting a run-out) may require throws to be performed with greater force and velocity, than those performed in training. This proposed higher intensity of throwing may be responsible for the slightly higher incidence of shoulder injuries in matches when compared to practices, found in this study. Orchard et al.[25] described a similar trend for hamstring injuries related to sprinting intensity in the different formats of cricket matches.

Notably, it has been suggested that a one-week spike in throwing workload may trigger shoulder injuries.[14] In addition, when cricketers exceed 75 throws per week, shoulder injury risk has been found to increase by 1.73 times.[14] This weekly throwing load is often exceeded when considering the number of throws performed in fielding drills or batting throw-down sessions and may be further exacerbated by warm-up sessions specifically when playing multiple day matches or limited over matches in quick succession of each other. Throwing exposure in terms of training hours or number of throws per training session was not investigated in this study but the poor mean KJOC scores for this cohort suggest that throwing load during training or match sessions should be monitored in a similar fashion to bowling load during a net session. Further, it is suggested that competitive small-sided cricket games, such as "Battlezone"[26] be implemented in cricket training sessions to ensure throwing intensity mimics the requirements of matches.[27]

The overall injury prevalence of the entire cricket cohort illustrates similar injury risk across all formats of the game. This is in contrast to the trend reported in the literature with injury risk highest in T20 matches, followed by one-day and then multiple day (5-day and 4-day) matches.[16] Interestingly, the national squad was found to be more susceptible to shoulder injury in the longer formats of the game, while the opposite is true for the franchise squads. A comparison of both annual injury incidence and prevalence between national and franchise squads (Annual incidence: 3.04 ± 0.0 vs 0.18 ± 2.32 shoulder injuries per player per year, $p = 0.09$; combined match prevalence: $7.1 \pm 0.0\%$ vs $0.1 \pm 0.15\%$, $p < 0.0001$) highlights that injury risk is similar, yet injury frequency increases with progression in level of participation and play. This may be attributed to the higher intensity and workloads of training and matches,[16] longer season duration, as well as participation in professional tournaments such as the Indian Premier League and Australian Big Bash League.

Cricketers with a greater risk of shoulder injury were those who had previously sustained a shoulder injury. This agrees with findings previously reported by Stretch[1] and Giles and Musa[8] highlighting history of previous shoulder injury as a significant risk factor.

It is possible that the shoulder may demonstrate a functional instability following initial injury, similar to that described for lateral ankle ligament sprains.[28] Failure to detect and adequately rehabilitate the associated neuromuscular[29] and proprioceptive[30] deficits known to occur with shoulder injury, may result in the development of latent pathology or irreversible structural damage to the shoulder. Consequentially, changes to movement sequencing and the biomechanical patterns of throwing and/or bowling are thought to occur and may be exacerbated by weak GH external rotators and scapula dyskinesis.[31] Ultimately, the load on the shoulder joint is attenuated. Further research is required to determine the factors associated with recurrent shoulder injuries in cricket.

This study was conducted over a single season and utilised a small sample. Future studies should consider a multi-centre study of cricketers performing at equivalent levels, as well as a longer period of injury surveillance. These suggestions will improve statistical power and allow for player speciality/position comparisons with shoulder injury risk. Although this study based clinical diagnosis on the WHO ICD list,21 diagnostic error may have occurred where medical staff have less clinical experience in cricket. Thus, the diagnostic accuracy and inter-rater reliability of cricket medical staff needs to be determined. Finally, the possibility that cricketers completed the KJOC score inaccurately needs to be considered. This may have occurred due to fear of potential loss of national/franchise contracts through injury, or as a result of the time-elapsed between injury sustained and completion of the post-season KJOC score. Therefore it is suggested that future studies determine whether pre- and post-season KJOC scores can be effectively compared to determine shoulder injury risk.

5. Conclusion

This study is the first to report both time-loss and non-time-loss shoulder injury in elite South African cricketers. A history of previous shoulder injury and a decreased functional ability score for the shoulder were associated with an increased risk of injury. Despite injury, most cricketers are generally able to continue participating in practices and matches, by altering their throwing technique or fielding position which may influence performance. Consequentially, the importance of documenting all injuries, irrespective of potential time lost to practices and matches; as well as a measure of function, in the definition used for shoulder injury surveillance studies in cricket, is highlighted.

Conflicts of interest

No conflicts of interest.

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References

1. Stretch RA. Cricket injuries: a longitudinal study of the nature of injuries to South African cricketers. *Br J Sports Med* 2003; 37:250–253.
2. Orchard J, James T, Alcott E et al. Injuries in Australian cricket at first class level 1995/1996 to 2000/2001. *Br J Sports Med* 2002; 36:270–275.
3. Leary T, White JA. Acute injury incidence in professional county club cricket players (1985-1995). *Br J Sports Med* 2000; 34:145–147.
4. Orchard J, James T, Portus M. Injuries to elite male cricketers in Australia over a 10-year period. *J Sci Med Sport* 2006; 9:459–467.
5. Orchard J, Newmand D, Stretch R et al. Methods for injury surveillance in international cricket. *J Sci Med Sport* 2005; 8(1):1–14.
6. Hodgson L, Gissane C, Gabbett TJ et al. For debate: Consensus injury definitions in team sports should focus on encompassing all injuries. *Clin J Sports Med* 2007; 17:188–191.
7. Ranson C, Gregory PL. Shoulder injury in professional cricketers. *Phys Ther Sport* 2008; 9:34–39.
8. Giles K, Musa I. A survey of glenohumeral joint rotational range and non-specific shoulder pain in elite cricketers. *Phys Ther Sport* 2008; 9:109–116.
9. Green RA, Taylor NF, Watson L et al. Altered scapula position in elite young cricketers with shoulder problems. *J Sci Med* 2013; 6:22–27.
10. Arora M, Shetty SH, Dhillon MS. The shoulder in cricket: what's causing all the painful shoulders? *J Arthrosc Joint Surg* 2015:1–5.
12. Stretch RA. A review of cricket injuries and the effectiveness of strategies to prevent cricket injuries at all levels. *S Afr J Sports Med* 2007; 19(5):129–132.
13. Milsom NM, Barnard JG, Stretch RA. Seasonal incidence and nature of cricket injuries among elite South African schoolboy cricketers. *S Afr J Sports Med* 2007; 19(3):80–84.
14. Saw R, Dennis RJ, Bentley D et al. Throwing workload and injury risk in elite cricketers. *Br J Sports Med* 2011; 45:805–808.
15. Bartlett RM. The science and medicine of cricket: an overview and update. *J Sports Sci* 2003; 21(9):733–752.
16. Orchard J, James T, Kountouris A et al. Changes to injury profile (and recommended cricket injury definitions) based on the increased frequency of Twenty20 cricket matches. *J Sports Med* 2010; 1:63–76.
17. Alberta FG, ElAttrache NS, Bissel S et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med* 2010; 38(5):903–911.
18. Kraeutler MJ, Ciccotti MG, Dodson CC et al. Kerlan-Jobe Orthopaedic Clinic overhead athlete scores in asymptomatic professional baseball pitchers. *J Shoulder Elbow Surg* 2013; 22:329–332.
19. van Kampen DA, Willems WJ, van Beers LW et al. Determination and comparison of the smallest detectable change (SDC) and the minimal important change (MIC) of four-shoulder patient-reported outcome measures (PROMs). *J Ortho Surg Res* 2013; 8(40) http://www.josr-online.com/content/8/1/40.
20. Orchard J, Ranson C, Olivier B et al. International consensus statement on injury surveillance in cricket: a 2016 update. *Br J Sports Med* 2016;(0):1–7.
21. The World Health Organisation.*International statistical classification of diseases and related health problems*, 10th revision, 5th edition, In: Geneva: The World Health Organisation, editor, Malta, World Health Organisation, 2016.
22. Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. *J Athl Training* 2006; 41(2):207–215.
23. Bahr R, Holme I. Risk factors for sports injuries - a methodological approach. *Br J Sports Med* 2003; 37:384–392.
24. Domb BG, Davis JT, Alberta FG et al. Clinical follow-up of professional baseball players undergoing ulnar collateral ligament reconstruction using the new Kerlan-Jobe Orthopaedic Clinic overhead athlete shoulder and elbow score (KJOC score). *Am J Sports Med* 2010; 38:1558–1563.
25. Orchard J, Kountouris A, Sims K. Risk factors for hamstring injuries in Australian male professional cricket players. *J Sport Health Sci* 2017:1–4.
26. Renshaw I, Chappell G, Fitzgerald D et al. The battle zone: Constraint-led coaching in action. *Conference Sci Med Coaching Cricket* 2010:181–184.
27. Vickery W, Dascombe B, Duffield R et al. Battlezone: an examination of the physiological responses, movement demands and reproducibility of small-sided cricket games. *J Sports Sci* 2013; 31(1):77–86.
28. Hertel J. Functional Instability Following Lateral Ankle Sprain. *Sports Med* 2000; 29(5):361–371.
29. Cools AM, Johansson FR, Borms D et al. Prevention of shoulder injuries in overhead athletes: A science-based approach. *Braz J Phys Ther* 2015; 19(5):331–339.
30. Safran MR, Borsa PA, Lephart SM et al. Shoulder proprioception in baseball pitchers. *J Shoulder Elbow Surg* 2001; 10:438–444.
31. Møller M, Nielsen RO, Attermann J, Wedderkopp N, Lind M, Sørensen H et al. Handball load and shoulder injury rate: a 31-week cohort study of 679 elite youth handball players. *Br J Sports Med* 2017; 51:231–237.

Further reading

11. Bell-Jenje TC, Gray J. Incidence, nature and risk factors in shoulder injuries of national academy cricket players over 5 years - a retrospective study. *S Afr J Sports Med* 2005; 17(4):22–28.