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Are Fast-Bowlers Prone to Back Injuries? Prevalence of Lumbar Spine Injuries in Fast-Bowlers: Review of MRI-Based Studies

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Background: Fast-bowlers in cricket subject their spines to repetitive stress.
Objectives: The aim of this study was to review the prevalence of lumbar spine injuries among fast-bowlers.
Materials and Methods: Medline and embase searches were performed. Further, the authors canvassed the reference list of available articles and used other search engines such as Google Scholar to identify a total of nine studies.
Results: The prevalence of lumbar disc degeneration in fast-bowlers ranges from 21-65% with an incidence rate of 15% per year, and the prevalence of lumbar spine bony abnormalities ranges from 24-81%. Factors associated with lumbar spine injury in fast-bowlers are classified into un-modifiable (age) and modifiable (more intense bowling workload and mixed-bowling technique).
Conclusions: Fast-bowlers have a high prevalence of lumbar spine injuries. Appropriate interventions, such as educational sessions, may be able to modify risk factors such as bowling workload and bowling technique and thus reduce injury prevalence.

Keywords: Spine Injury; Back Injury; Systematic Review; Fast-Bowler; Athletes

1. Background

Cricket is a safe sport with a relatively low overall player injury rate but, due to the extreme stress of repetitive vigorous spinal loading, fast bowlers are highly prone to injuries, with bowlers accounting for 40-45% of all injuries suffered by cricketers (1, 2). Lumbar spine injuries are especially common, accounting for one-fifth to one-third of all injuries sustained by cricketers (1-3). It is suggested that acute injuries are three times as common as chronic injuries (1) but defining the age of lumbar bone stress injuries can be difficult. Fast-bowlers subject their spines to repetitive sagittal plane and rotatory movements over many years, placing them at an increased risk of back injuries. Despite multiple studies in this field, there has been no consensus on the prevalence rates of lumbar spine pathology in fast-bowlers or the specific risk factors that increase injury risk for lumbar spine injuries in fast-bowlers. There is consensus, however, on the causal nature of pathology, with the majority of injuries occurring during the actual bowling action (delivery stride and follow through) rather than the run-up (1).

2. Objectives

The aim of this review was to assess the prevalence of lumbar spine injuries in fast-bowlers, including injuries to both the disc and the bony elements of the lumbar spine.

3. Materials and Methods

Medline and embase searches were performed (search terms: "Cricket" AND "Lumbar spine injury"; "Fast bowlers" AND "Lumbar spine injury"; "Cricket" OR "Fast bowlers" AND "Back injury"; "Cricket" OR "Fast bowlers" AND "Lumbar disc degeneration"; "Cricket" OR "Fast bowlers" AND "Lumbar spondylolysis"; and other associated synonyms) on January 2013. Further, the authors canvassed the reference list of available articles and used other search engines such as Google Scholar to identify a total of nine studies. Inclusion criteria were studies that evaluated the prevalence of lumbar spine injuries in fast-bowlers using MRI.

4. Results

4.1. Prevalence of Lumbar Disc Changes in Fast-Bowlers

Due to the repetitive stresses fast-bowlers place on their spines, especially at the point of maximal load transmission during the delivery stride, it is postulated that the process of disc degeneration seen in the general population will occur at a much higher rate in fast-bowlers. Prevalence rates of lumbar disc injury have a wide range. Elliott et al. (2002) found in a group of fast bowlers with

mean age of 17.9 years that 65% had at least one abnormal disc (4). Consistent with two earlier studies (5, 6). In contrast, Burnett et al. (1996) and Crewe et al. (2012) found that younger bowlers (under 15 years) had prevalence rates of 21-35% versus older bowlers (over 15 years) who had higher prevalence rates (43-58%) of lumbar disc pathology of at least one level (7, 8). Thus, it can be seen that prevalence ranges from 21-65%, with older bowlers having higher prevalence rates, although it must be recognized that older age may also represent increased years of spinal loading. Burnett et al. (1996) also deduced an annual incidence rate of 15% based on their follow-up after 2.5 years (21% initial versus 58% at follow-up) (7). The severity and site of pathology also varies among studies. Crewe et al. (2012) examined 25 discs, of which 64% of changes occurred at the lower two lumbar levels. Most cases were of moderate severity (52%), followed by mild (44%), and then severe (4%) (8) This is in contrast with the study by Ranson et al. (2005) who found that 33% of bowlers had severe degeneration, with 17% of all bowlers having severe degeneration at multiple levels (6). Degeneration at lower two lumbar levels was found in 62% of bowlers in this group. Thus, the prevalence of severe disc degeneration in fast-bowlers ranges from 4-33%, while the site of changes seem more consistent with the lower two lumbar levels being involved in 62-64% of cases (6).

4.2. Prevalence of Lumbar Bone Changes in Fast-Bowlers

The prevalence of lumbar spondylolysis in the general population is between 3 and 6% (9), although in young athletes presenting to sports medicine centres it may be as high as 48.5% (10). Prevalence rates among fast-bowlers have been postulated to be much higher than this figure due to the repetitive stress nature of the profession. MRI has allowed sports medicine clinicians to better visualize the nature of the bony injury. Essentially, the role of MRI is to determine if there is a pars interaticularis bone defect, whether the defect is acute or chronic based on the nature of the defect margins, and if there is an acute element to the defect, most often represented as bony oedema. Ranson et al. (2005) found that fast bowlers had twice the prevalence of pars interarticularis abnormalities versus controls on the non-dominant side (81% vs. 36%) (6). Furthermore, four times the number of pars abnormalities were found on the non-dominant side in fast bowlers compared with their dominant side (81% vs. 19%) (6). A limitation of this study is that controls participated regularly in other sporting activities, including contact sports, which also put higher stresses on the spine than a sedentary general population, and as such the prevalence in controls may be higher than normal for the general population. These figures are higher than previous studies (Figure 1). Thus the range of pars injuries in fast bowlers is between 24 and 81%. The exact causative nature of pars interarticularis bone stress injury is controversial, as is the terminology to define the injury. Ranson et al. (2005) found that the most common abnormality of the pars was chronic.

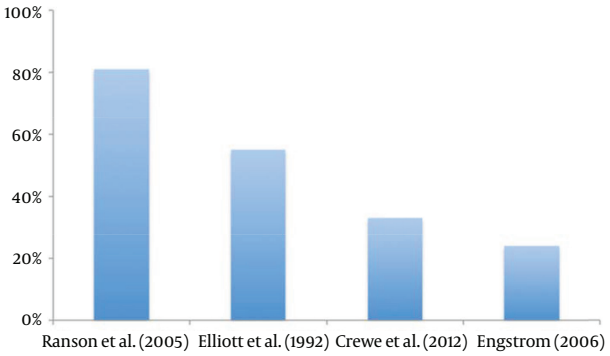

Figure 1. Prevalence of pars interarticularis injuries in fast-bowlers in various studies based on MRI findings. Overall range is 24-81%.

5. Discussion

Stress reaction (53%), followed by chronic stress fracture (24%), and sub-total stress fracture (14%) (6). Of note, the majority (86%) of chronic stress fractures were on the non-dominant side, whereas chronic stress reactions were twice as common on the dominant side versus the non-dominant side. The same group in a later study found that the prevalence of acute bone stress was 54% among fast-bowlers and that this was a predictor of future stress fractures (11). However, it is possible that the acute bone stress is an adaptive change and that restriction of bowling workloads at this stage may decrease stress fracture risk. In contrast, in their cohort, Crewe et al. (2012) found that the most common pars abnormality was a sub-total stress fracture (38% of bowlers) (8). Thus the nature of bone injury incurred by fast-bowlers requires further work. The pattern of bone injury appears more precise with most studies confirming that the lower two lumbar levels (L4 and L5) are most commonly affected (12) (6, 8, 11).

5.1. Bowling Technique and Lumbar Injuries

Bowling technique has long been postulated as a contributing factor to back injury in fast-bowlers. Bowling techniques can be broadly classified into three groups: front-on, side-on and mixed (combination of front-on and side-on) (13). The biomechanical characteristics of each technique are described in Table 1. An 'optimal' fast bowling technique is defined as one that allows the bowler to ball fast with a relatively low injury risk (13). The side-on technique has been advocated as the correct and most effective way to bowl. A mixed action leads to excessive lumbar spine extension and rotation before ball release, and subsequently increased spinal counter-rotation through the delivery stride. The mixed bowling

Table 1. Biomechanical Characteristics of Front-on, Side-on and Mixed Bowling Techniques (Modified From: Bartlett et al. 1996)

Bowling technique	Run-up Speed	Rear foot Position	Shoulder Alignment at Rear Foot Strike (Angle Between Wickets and Line Joining Shoulder)
Side-on	Relatively low	Parallel to Popping Crease	Approximately 180 Degrees
Front-on	Higher run up Speed Compared to Side-on	Towards Direction of ball Travel After Release	Greater than 180 Degrees
Mixed	Variable run up Speed	Transition from front-on to side-on Alignment During Delivery Stride	Transition From Front-on to Side-on Alignment During Delivery Stride

technique, due to the high biomechanical forces imparted on the spine, has been proposed to lead to a higher incidence of spinal injuries and back pain in fast-bowlers, especially the incidence of spondylolysis (14). A review of the literature on fast-bowlers and back injuries conducted over 15 years ago found sufficient evidence in the literature for a strong association between injury to the lower back and the use of mixed technique, even for bowlers in their teens (13). The higher risk may be related to the spine adopting a rotated and hyperextended position at front foot strike when ground reaction forces are high (15), or to biomechanically inferior trunk rotations, hyper-extension, lateral flexion of spine during delivery, and high axial compression, versus non-mixed bowlers (16). Furthermore, significant associations have been found between lumbar spine injuries and transverse plane Counter-rotation of shoulder alignment (line joining acromion processes) of greater than 40 degrees in some studies (15, 17) and greater than 20 degrees in another study (7). Thus, a host of biomechanical factors make mixed bowlers more susceptible to injuries and these aspects should form the basis of appropriately designed interventions. Bowling workload and lumbar injuries being a repetitive stress profession, a higher workload is postulated to increase the incidence of lumbar spine pathology. Lumbar bony injuries, as with any bone stress injury, are ultimately due to an inability of the bone to adapt to the loading forces applied to it. In their study of 44 Australian junior fast bowlers, Dennis et al. (2005) found a significant relationship between bowling workload and injury. Seven bowlers sustained back injuries, and these injured bowlers bowled more frequently and had shorter rest periods between bowling sessions than their uninjured colleagues. Bowlers with an average of more than 3.5 rest days between bowling were at significantly less risk of injury than those with an average of less than 3.5 rest days (18). Bowlers who bowled more than 50 deliveries per day and who bowled on average more than 2.5 days per week were at an increased risk of injury (18). In their study of 28 elite fast bowlers, Hulin et al. (2012) found that acute spikes in fast-bowling workload were associated with increased injury risk (19). However, a limitation of this study is the use of subjective assessment of perceived exertion during bowling. Thus, higher workloads, acute spikes in workload, and shorter rest intervals predispose bowlers to back injuries, suggesting a direct relationship between spinal loading through bowling activity and injury. Role of interventions in reducing lumbar injuries Based on our review, we recommend further developing and defining targeted interventions aimed at bowling technique and bowling workload to reduce the high prevalence of lumbar injuries among fast-bowlers. With respect to bowling technique, a sound understanding of bowling biomechanics is necessary prior to the design and implementation of any intervention. Coaching staff need to encourage fast-bowlers to adopt a non-mixed bowling technique, and instruct them in how best to achieve this outcome. This strategy was implemented by Elliot et al. (2002) as a series of educational interventions for their cohort of 143 bowlers (49 front-on or side-on; 94 mixed technique; mean age 13.3 years) (4). The educational intervention (total 6 sessions over a period of 3 years) took the form of educating bowlers, parents and coaches on the advantages of a non-mixed bowling technique and advising mixed bowlers to adopt a non-mixed technique (20% had safe technique at start of study versus 67% at end of study, despite only limited intervention over a prolonged time period). Overall, 24% of bowlers had lumbar disc degeneration at the start of the study, and 33% at the end of study period, suggesting prevalence and incidence rates much lower than the before-mentioned literature. Further, only one of the safe (non-mixed technique) bowlers sustained new lumbar disc degeneration versus 20 new cases in the mixed bowler group. With respect to bowling workload, current and future fast-bowlers need to be encouraged and educated in regard to manage bowling workloads, where possible, and to increase rest periods between matches and to avoid large fluctuations in workload over short time frames. As cricket becomes increasingly commercial, and with an overhanging paradigm of franchise culture, there is a need for bowlers themselves to take responsibility for their bodies and discuss with management an appropriately designed timetable of bowling workload to decrease injury risk. Cricketers in general and fast-bowlers in particular, are prone to lower back injuries. The prevalence of lumbar disc degeneration in fast-bowlers ranges from 21-65% with an incidence rate of 15% per year, and the prevalence of lumbar bone abnormalities ranges from 24-81%. Older age, a mixed bowling technique and high bowling workload are asso-

ciated with a higher prevalence of lumbar injuries. There is a need for appropriately designed interventions targeting the modifiable factors.

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