DOES CRICKET FAST BOWLING LUMBAR SPINE KINEMATICS CONTRIBUTE TO LUMBAR BONE STRESS INJURY?

Peter Alway[1], Paul Felton[2], Nick Peirce[3], Rob Kerslake[4], Katherine Brooke-Wavell[1] and Mark King[1]

School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, United Kingdom[1]
Department of Science and Technology, Nottingham Trent University, Nottingham, United Kingdom[2]
Department of Science and Medicine, England and Wales Cricket Board, Loughborough, United Kingdom[3]
Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom[4]

Lumbar bone stress injuries (LBSI) have the highest prevalence of any injury in cricket. The purpose of this study was to determine differences in lumbar spine kinematics between fast bowlers who avoid LBSI and those who sustain LBSI. 45 elite male fast bowlers completed 6 maximum effort deliveries captured by a motion analysis system. Upper and lower lumbar spine joint angles were reported at key instances and compared between groups. MRI and medical records revealed current and future incidence of LBSI. 47% of fast bowlers were diagnosed with LBSI. While no statistically significant differences in lumbar spine joint angles between groups were observed, LBSI cases demonstrated non-statistically significantly greater upper lumbar spine extension at BFC, FFC and maximal value which warrants further investigation.

KEYWORDS: Fast bowling, bone stress injury, kinematics, lumbar spine

INTRODUCTION: Lumbar bone stress injuries (LBSI) are caused by microdamage accumulating at a rate greater than the repair processes of bone (Warden & Burr, 2019). They exist on a continuum which increases in severity from a stress response through to multi-level stress fracture (Warden, Burr, & Brukner, 2006, Figure 1). Time loss can exceed 8 months and is the most prevalent injury in cricket (Orchard, Kountouris, & Sims, 2016). In cricket fast bowlers, they are commonly observed at the neural arch of L4 or L5, contralateral to the bowling arm (Alway, Brooke-Wavell, Langley, King, & Peirce, 2019).

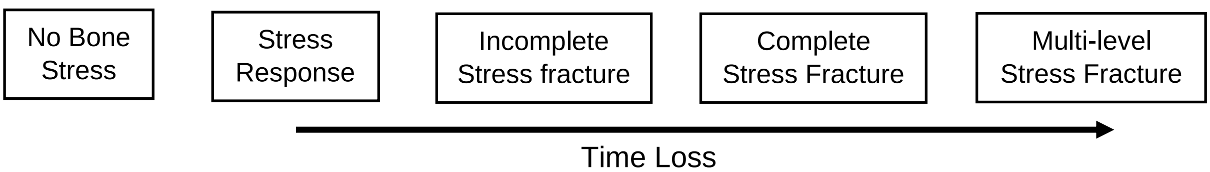

Figure 1: Lumbar Bone Stress Injury Continuum.

A risk factor identified for LBSI is technique, which can directly affect the magnitude and direction of strain on bone (Bennell, Matheson, Meeuwisse, & Brukner, 1999). Lumbar spine joint angles during fast bowling is multiplanar and can exceed maximum active range of motion (Ranson, Burnett, King, Patel, & O'Sullivan, 2008). Finite element modelling of lumbar spine movements has suggested that excessive lumbar rotation and extension puts the greatest load upon the neural arch of the lumbar spine (Chosa, Totoribe, & Tajima, 2004), and suggested to contribute to LBSI, however this is yet to be confirmed in empirical studies. Previous research investigating lumbar spine joint angles and LBSI in fast bowlers has been inconclusive, possibly due to using a single segment lumbar spine, or far removed derivatives of lumbar spine motion. This study aims to determine if lumbar spine joint angles differs between elite fast bowlers who sustain a LBSI and those who do not, using a two-segment lumbar spine.

METHODS: 45 elite male fast bowlers declared as match-fit by a physiotherapist completed a minimum of 6 deliveries of maximal effort bowling captured by an 18 camera VICON MX system (300 Hz, OMG Plc, Oxford, UK) in an indoor cricket specific facility. Retro-reflective markers were attached to participants at the spinous process of L5, L3, L1 and 5cm bilaterally to the spinous process of L4 and L2 to create upper (L1-L3) and lower (L3-L5) lumbar spine segments, (adapted from Seay, Selbie, & Hamill, 2008, Figure 2), as well as 2 markers bilaterally at the posterior superior iliac spine and anterior superior iliac spine to create a pelvis segment. A ZXY Euler angle decomposition was used to calculate upper and lower lumbar spine angles, which corresponded to the angle between itself and the segment directly inferior.

Figure 2: Location of markers used to define upper and lower lumbar spine segments.

The trial with the greatest ball velocity from each participant was analysed to determine joint angles in sagittal, frontal and transverse planes at back foot contact (BFC), front foot contact (FFC), ball release (BR) and the maximal value. Good repeatability (ICC = 0.98) has been shown between trials for measurements of whole body joint angles in fast bowlers (Felton, Lister, Worthington, & King, 2019), suggesting that a single trial is an adequate representation of technique for each bowler. Trials were filtered using a fourth order low pass Butterworth filter at 10Hz. No static trial was used to preserve the natural posture of the lumbar spine. Participants received a lumbar MRI (3.0T Discovery MR750w, GE Healthcare, Milwaukee, USA) which was reported by one radiologist to determine LBSI. Medical history was used to record any LBSI which occurred subsequently. To compare kinematics between groups an unpaired t-test was used. If the normality was violated a Mann-Whitney U-test was used. Cohen's *d* was used to measure effect size.

RESULTS: 21 (47%) fast bowlers were diagnosed with a LBSI following biomechanical assessment of their bowling action. 16 were diagnosed on the same day as the bowling assessment, and 5 were diagnosed in the 2 years subsequent (Mean [Range]: 305 [52 – 675] days). There was no statistically significant difference in age, height, body mass and bowling velocity between groups (Table 1). Further, there were no statistically significant differences in any lumbar spine joint angle between groups (Table 2).

Table 1: Mean (SD) characteristics between LBSI and uninjured fast bowling groups.

Variable	LBSI (n=21)	Uninjured (n=24)	*P*
Age	18.96 (1.72)	19.94 (2.57)	0.26
Height (m)	1.87 (0.06)	1.89 (0.06)	0.24
Body Mass (kg)	82.61 (7.68)	83.08 (10.92)	0.53
Bowling Velocity (m/s)	34.03 (1.76)	34.17 (2.26)	0.83

Table 2: Mean (SD) lumbar spine joint angles (°) between LBSI and uninjured groups at key instances. <180° denotes flexion, contralateral side flexion and contralateral rotation.

Segment	Axis	Key Instance	LBSI (n=21)	Uninjured (n=24)	*P*	Effect Size
Upper (L1-L3)	x	BFC	187 (6)	185 (5)	0.20[a]	0.37
		FFC	191 (6)	189 (8)	0.25[a]	0.35
		BR	175 (4)	175 (4)	0.95	0.02
		Max Flexion	175 (4)	175 (4)	0.82	0.07
		Max Extension	193 (6)	191 (7)	0.37[a]	0.28
	y	BFC	179 (4)	179 (4)	0.76	0.09
		FFC	176 (6)	177 (6)	0.79	0.08
		BR	175 (3)	176 (4)	0.79	0.08
		Max contralateral	170 (5)	169 (5)	0.71	0.11
		Max ipsilateral	181 (4)	181 (5)	0.91	0.03
	z	BFC	183 (3)	184 (3)	0.77	0.09
		FFC	171 (3)	172 (6)	0.51[a]	0.20
		BR	176 (3)	176 (3)	0.77	0.08
		Max contralateral	170 (3)	170 (5)	0.16[a]	0.43
		Max ipsilateral	184 (2)	185 (3)	0.79	0.09
Lower (L3-L5)	x	BFC	175 (4)	174 (7)	0.78	0.09
		FFC	181 (7)	180 (8)	0.56	0.18
		BR	170 (5)	169 (7)	0.50[a]	0.30
		Max Flexion	169 (6)	167 (7)	0.33[a]	0.25
		Max Extension	183 (6)	181 (8)	0.39[a]	0.26
	y	BFC	177 (4)	177 (6)	0.87	0.05
		FFC	167 (5)	167 (9)	0.74	0.10
		BR	175 (4)	173 (6)	0.35[a]	0.29
		Max contralateral	164 (5)	163 (8)	0.79	0.08
		Max ipsilateral	179 (4)	181 (6)	0.27[a]	0.34
	z	BFC	183 (2)	182 (3)	0.18[a]	0.41
		FFC	180 (4)	179 (3)	0.62	0.15
		BR	181 (4)	180 (4)	0.34[a]	0.29
		Max contralateral	177 (4)	177 (3)	0.15[a]	0.43
		Max ipsilateral	184 (3)	183 (3)	0.43	0.15

[a] *denotes small effect size (d ≥ 0.20 - ≤ 0.49)*

DISCUSSION: This study has demonstrated no statistically significant differences in lumbar spine joint angles between a prospective LBSI injury group and those who avoid subsequent LBSI. This suggests that lumbar spine joint angles alone may not contribute to LBSI, and greater contribution comes from other risk factors to LBSI.

While no statistically significant differences or large effect sizes were found between groups, injured fast bowlers demonstrated non-statistically significant greater upper lumbar spine extension compared with uninjured fast bowlers at BFC, FFC and maximal values. When coupled with the flexed position of the lower lumbar spine, this may suggest that fast bowlers who sustain LBSI have greater lumbar lordosis at these discrete time points which has been demonstrated to increase compressive and shear forces upon the neural arch of the vertebra (Shirazi-Adl & Parnianpour, 1999).

At FFC, both vertical ground reaction forces (Worthington, King, & Ranson, 2013) and contralateral lower lumbar side flexion are high, which decreases disc height between vertebra via compression (Kimura, Steinbach, Watenpaugh, & Hargens, 2001) and displacement of the disc to the ipsilateral side (Bogduk, 1997), reducing distance between vertebra, particularly on the contralateral side. With greater upper lumbar extension, it is plausible the distance between adjacent vertebra is further reduced, and may lead to repetitive and/or more forceful impact between the contralateral superior articular process of an inferior vertebra with the contralateral inferior margin of the neural arch of a superior vertebra (Ward & Latimer, 2005). This increases load at the point of contact, accelerating the failure of the contralateral neural arch (Ward et al. 2010). This mechanism would explain the unilateral presentation of LBSI in fast bowlers.

A limitation of this study is that fast bowlers may have changed technique following undergoing biomechanical assessment and when being diagnosed with LBSI. Many uninjured fast bowlers in this study are of an age where risk of LBSI is greater and may still sustain a LBSI. Future research should attempt to incorporate total body kinematics and kinetics as well as other risk factors to determine the aetiology of LBSI in elite cricket fast bowlers.

CONCLUSION: There was no statistically significant differences in lumbar spine joint angles between a prospective LBSI group and an uninjured group, which may suggest other joint rotations or other risk factors to LBSI may have a greater contribution to LBSI. Non-statistically significant greater upper lumbar spine extension may increase risk of LBSI and warrants further investigation.

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