The Presence of Known Biomechanical Risk Factors for Low Back Injuries in Junior Cricket Fast Bowlers

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Statement of Originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

29 March 2019

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List of Abbreviations

°	Degrees
>	Greater than
<	Less than
%	Percent
±	Plus or minus
*	Indicates significant different results
2D	Two-dimensional
3D	Three-dimensional
AH	Arm horizontal
ANOVA	Analysis of variance
Ant	Anterior
ASIS	Anterior superior iliac spine
AV	Arm vertical
BFA	Back foot angle
BFC	Back foot contact
BIC	Back foot initial contact
BMC	Bone mineral content
BMD	Bone mineral density

BR	Ball release
Bul	Bulging
BM	Body mass
CI	Confidence interval
CT	Computed tomography
cm	Centimetre
cm^2	Centimetre squared
CSA	Cross-sectional area
d	Cohen's d
DXA	Duel-energy X-ray absorptiometry
D.Degen	Disc degeneration
EMG	Electromyography
GRF	Ground reaction force
g	Gram
F_{ant}	Anterior force
FFC	Front foot contact
F_{lat}	Lateral force
F_{med}	Medial force
F_{post}	Posterior force
FTO	Front foot-ground take off

F_v	Vertical force
HR	High risk
ICC	International cricket council
Inj	Injured
kg	Kilogram
$km \cdot h^{-1}$	Kilometres per hour
Lat	Lateral
LJ	Left joint
LQ	Lower quarter
LF	Lateral flexion
LBP	Low back pain
m	Metre
m^2	Metres squared
min	Minute
mm	Millimetre
$m \cdot s^{-1}$	Metres per second
MRI	Magnetic resonance imaging
n	Sample size
N	Newtons
N/AD	Not addressed

N/AP	Not applicable
NR	Not reported
NS	Not stated
NSW	New South Wales
NTL	No time loss
NM	Newton metres
OSICS	Orchard sports injury classification system
p	Alpha
Post	Posterior
PS	Pedicle sclerosis
PSIS	Posterior superior iliac spine
QL	Quadratus lumborum
r	Pearson’s product-moment correlation coefficient
RJ	Right joint.
ROM	Range of motion
SA	Shoulder alignment
SCR	Shoulder counter rotation
SEBT	Star excursion balance test
SSA	Shoulder separation angle
SLDS	Single-leg decline squat

Spon	Spondylolisthesis
SPSA	Shoulder pelvis separation angle
TL	Time loss
Ver	Vertical
W	Watt
WL	Work load
y	Years

Abstract

Introduction: Injury prevalence rates of cricket fast bowlers increase over time. Fast bowlers lose 16% of potential playing time due to injury, while all other playing positions in cricket lose 5% of potential playing time. Most of the injuries of cricket fast bowlers occur in the lumbar region of the spine. Young fast bowlers have a higher risk of injury to the lower back compared to adult cricket fast bowlers and 37% - 55% of injuries among junior fast bowlers are in the lower back. Researchers have reported that bowling action is one of the main factors associated with low back injuries, with the mixed bowling action identified as having the highest-risk of injury. Hence, the first aim of this thesis is to examine biomechanical factors associated with low back pain and injury in fast bowlers through a systematic review of the literature. Secondly, a biomechanical analysis of junior cricket fast bowlers will be performed to established the presence of identified risk factors among junior fast bowlers, as well as to measure bone health and muscle symmetry.

Systematic review

Method: Seven electronic bibliographic databases including MEDLINE, EMBASE, SCOPUS, COCHRANE LIBRARY, WEB OF SCIENCE as well as SPORTDISCUSS were used as primary search sources. Eleven key words were used with three different combination formats in the electronic data bases searched. Three different factors including participant characteristics, biomechanical analysis, and the currency of the study were considered for the inclusion criteria. Methodological quality assessment of included articles was conducted using the McMaster University Guidelines and Critical Review Form for Quantitative Studies. Biomechanical data were extracted from the studies and summarised.

Results: Six articles were selected for the systematic review. All six were moderate to good quality according to critical appraisal scores, which ranged from 9 to 11 (Mean 9.5) out of 15. Three studies reported 3D biomechanical data and the other three studies reported 2D biomechanical data. Only one study investigated female participants, while all other studies investigated male participants. The mean age of the participants ranged from 13 to 27 years. Three studies out of six investigated junior state/club level fast bowlers and the other three investigated senior elite level fast bowlers. Out of these six included studies, only four studies used force plates to report cricket fast bowling kinetics. Higher lumbar lateral flexion power, lumbar lateral flexion moment, as well as lumbar flexion moments were the identified kinetic factors associated with lower back injuries. However, some conflicting findings were noticed, as three studies out of four which reported kinetic results did not report any association of the above-mentioned kinetic factors with lower back injuries. Higher hip flexion, shoulder alignment at back foot contact and at ball release, thorax lateral flexion at front foot contact and ball release, range of thorax lateral flexion, pelvis rotation at ball release and more importantly shoulder counter-rotation were identified kinematic factors that were associated with lower back injuries. However, similar to kinetic factors, there were some conflicting results reported, including one study that did not report any significant relationship between shoulder counter rotation and low back injuries.

Conclusion: Both kinetic and kinematic factors associated with low back injuries were identified through the systematic review. However, some conflicting findings were reported, indicating that further research is needed to investigate the validity of the identified biomechanical risk factors.

Experimental study

Method: Eleven junior male representative fast bowlers (mean age 13.8 ± 0.6 y, mean height 173.9 ± 5.3cm, mean weight 63.5 ± 5.7kg) were recruited from the Central Coast and Newcastle area, NSW, Australia. Each participant completed a spell of five overs at game pace. Three–dimensional (3D) kinematics (500Hz) and ground reaction forces (2000Hz) of the bowling action were recorded during the delivery stride and analysed in Visual 3D software. All participants underwent a whole-body Dual-energy X-ray absorptiometry (DXA) scan to examine bone health and muscle distribution.

Results: The majority (63.6%) of the junior fast bowlers used the mixed bowling action and the only other action used was the semi-open bowling action (36.7%). Biomechanical risk factors for lower back injuries, as identified in the systematic review, were observed in the entire study cohort. Greater shoulder counter rotation, shoulder alignment at back foot contact and ball release, thorax lateral flexion at front foot contact and ball release, range of thorax lateral flexion, pelvis rotation at ball release and hip flexion are identified kinematic factors, which were significantly higher in the mixed bowling action group compared to the semi-open bowling action group. Furthermore, higher lumbar lateral flexion power, lumbar lateral flexion moment and lumbar flexion moment are identified kinetic factors, which were significantly higher in the mixed bowling action group compared to the semi-open bowling action group. No significant differences were observed for bone mineral density or lean mass between bowling action groups in any region of the body. Furthermore, no differences in bone mineral density and lean mass were found between the dominant and non-dominant side of the body.

Conclusion: Although several studies identified the mixed bowling action as a high-risk bowling action for low back injuries, the majority of the junior fast bowlers in this study used the mixed action. These junior bowlers also demonstrated several identified kinematic and

kinetic risk factors for lower back injuries. It is alarming that 63.6% of junior fast bowlers select the mixed bowling action, as this may lead to minor to severe injuries and potentially early dropout. It appears better education is needed for coaches and athletes to alert them to higher risk of lower back injuries for bowlers using the mixed action.