ORIGINAL RESEARCH PAPER

Sport Science

BIOMECHANICAL ANALYSIS OF FAST BOWLERS WITH DIFFERENT BOWLING ACTIONS TOWARDS TRAINING OPTIMISATION AND INJURY RISK MANAGEMENT.

KEY WORDS: Injury, Biomechanics, Cricket, Fastbowling, Video Analysis Software

Dr. Ashish Kumar Singh Assco. Prof., CUSB, Gaya

Dr. Pankaj Pandey Asst. Prof., ASPESS, Amity University

ABSTRACT

The present study on biomechanical analysis of fast bowlers with different bowling actions toexplore the kinematic and kinetic differences and their impact on performance and injury risk.Bowling actions of fast ballers with side action, front-on action and mix-on action techniques wherevideo graphed and analysed using Kenova movement analysis software against identified techniquefactorscriticaltowards trunkinjury.The findingsof this study provide valua bleinsights for coaches, biomechanics, and sports scientists in understanding the biomechanics of fast bowling andoptimizingtraining methodologies.

INTRODUCTION

Fundamental components for a successful fast baller is depended on being relatively injury free andconsistently achieving high standards of performance.Previously fast bowling research has studiedthe relationships between fast bowling and injury(Foster, John, Elliott, Ackland, & Fitch, 1989),literature evidence on fast ballers action, suggest that specific bowling techniques pose a higher riskof a lumbar vertebral stress injury. According toPortus, Mason, Elliott, & Pfitznner (2004) fastbowling is a dynamic activity requiring bowlers to run-up and repeatedly delivers the ball at highspeeds. Ball release speed is a major contributor to fast bowling success as it reduces the time forbatsman to interpret the path of the ball and make decisions regarding which shot to play. Ininternational matches, bowlers may perform as many as 180 deliveries a day. Although cricket isgenerally considered a low-injury sport, fast bowlers have injury rates comparable to contact sportssuch as Australian Rules football and the Rugby football codes(Orchard, James, Alcott, Carter, &Farhart, 2002) . Lower back injury is the most prevalent injury among fast bowlers, with lumbarstress fractures which occur predominantly on the non-dominant (non-bowling arm) side accountingfor the most lost training and playing time (Gregory , Batt, & Kerslake, 2004).The fast bowlingaction can be classified as side-on, front-on, semi-front-on or mixed depending on the orientation ofthe shoulder hip axes and back foot alignment during delivery. Bowlers who use the side-on andfront-on techniques are not at as much risk of injury as those who use the mixed technique. Thesemi-front-on actionis a new technique that is based on thesame principles as thetwo `safeactions', where the alignment of the shoulders and hips are in the same direction. A combination ofthese factors has been linked to an increased incidence of radiological features in the thoracolumbarspine, including spondylolysis, inter-vertebral disc degeneration and spondylolisthesis (Foster &Elliot1989; Often concurrently with these high loads, the trunk is flexing laterally and rotating in an efforttomaximizethespeedofthebowling-shoulder. Arange ofmechanical variable shavebeencommonly linked with lower back injury and include, but are not delimited to: shoulder alignment counterrotation(CR),hip-should eralignment separationangle(SA),frontkneeflexion(KF)and trunk lateral flexion (TLF) Foster & Elliot, (1989)(Burnett, Elliot, & Marshall, 1995). Ranson,Burnett, & KIng, (2008)proposed that concurrent lower trunk extension, ipsilateral rotation andextreme contralateral sideflexion during the early part of the front foot contact phase of the bowlingaction may be an important mechanical factor in the aetiology of this type of injury. However, theyhighlighted the need for further prospective and mechanical modelling studies to determine therelationship between lower back kinematics, variables previously found to be related to back injury(e.g. shoulder counter-rotation), and lumbar spine stress injuries in fast bowlers. (Burnett, Elliot, &Marshall, 1995)found that bowlers using the mixed action, in addition to having a large amount oftrunk twisting occurring during the shoulder counter-rotation, also had more twist at release (greaterpelvis-shoulder separation angle). This is of some concern as the trunk becomes increasingly flexedafter release.Burnett, Elliot, & Marshall, (1995)suggested that there may be a mechanism forincreased vulnerability of the posterior annulus to injury when twisting is combined with flexion.Limited research has been published on the critical factors associated with faster ball release speeds(Davis& Blanksby, 1976);(Burden,& Bartlett,,1990);(Stockill& Bartlett, 1993)

METHODOLOGY

The participant of the study consisted of 30 male cricket fast medium bowlers bowling side on,bowl front on, and bowl mixed on. The bowlers' ages ranged from 18 to 25 years, and they weredivided into three groups according to their bowling style, namely side on, front on, and mixed on.The focus of the study was low back pain among fast medium bowlers, and specific biomechanicalfactors were examined,includinghipandshoulderalignmentwiththevertic alline,pelvistoshoulder angle, and hip to shoulder angle differences. Before final attempt for video recording. Eachparticipantcarried outthree bowlingactiontrailswith dominance.

Videography Technique

The chosen variables, including hip and shoulder alignment with the vertical line, pelvis-to-shoulderanglevariation, andhip-to-shoulder angle, weremeasured usingthe video capturetechnique.

The Sony HD camera was utilised by the investigator to record videos. In this investigation, thebowlers' bowling motion was recorded using a camera. To record the bowling action, twocameraswere positioned, one camera positioned 8 metres away perpendicular to the activity area on sagittalplane, another camera positioned 5 meters away on frontal plane for posterior view.A camera with65 frames per second, positionedattheheightof1.30metresabovethegroundontripo dwasappliedtorecordthetrials.Acromialprocessesontheshou ldersandtheposteriorsuperioriliacspine of the pelvis were marked with markers, and subjects were instructed to wear simple clothingto avoid any ambiguity. The camera was positioned parallel to the popping crease and towards thebowler's back. Every participant was requested to bowl three times, and at the same instant the ballwasreleased, photosweretakeninposterioranteriorperspective.Thecaptur edvideowastransferred to the computer, where it was examined with the help of Kinovea motion analysissoftware andafewvariables were measure dindegrees. Withtheaidofthesoftware' sprotractortool, the hip alignment was measured as the angle between the pelvic positions and the verticalline.

Using the protractor tool in the software, the angle between the shoulder's location and the verticalline was measured to determine the shoulder alignment. With the aid of the software's protractortool, the hip to shoulder alignment angle was measuredbetweenthepositionsoftheshoulderandhip.

DataAnalysis
The collected data were analysed through qualitative technique against standards criterion measuresconducivefor injury prevention among fast ballers.

Results and Findings
To classify the fast bowling techniques, a modified criteria fromBurnett, Elliot, & Marshall, (1995)and Portus,Sinclair, Burke,& Farhat(2000)

***Side-on action*:**
a shoulder segment angle less than 210 degree at back foot contact, hip-shoulder separation angle less than 30 degree at back foot contact, and shoulder counter-rotation less than 30degree.

***Front-on action*:**
a shoulder segment angle greater than 240 degree at backfoot contact, a hipshoulde rseparation anglelessthan30 degreeatbackfootcontact,and,shouldercounter-rotation less than 30degree.

Mixedaction:
a hip-shoulderseparation angle equalto orgreater than 30 degree atback footcontact,or, shoulder counter-rotationequal to or greater than30 degree.

Movements	Degree onmovement	Muscle Engagement (Ranking)	Type ofmotion	Bodysegment	Bowlingaction	Muscleaction
Hip-shoulder Separation	Hip-shouldersep arationangle equalto or greaterthan 30degrees atback footcontact	High	flexion	When performing a rotatingmovement, this describes theangle of separation betweenthe hips and shoulders.(Portus,, Sinclair, Burke,, &Farhat,, 2000)(Burnett, Elliot,& Marshall, 1995) Whendoing tasks like pitching,swinging a golf club, orthrowing a ball, it isfrequently measured at theinstant of back foot contact.The hips and shoulders aresignificantly separated duringthis portion of the movementif the hip-shoulder separationangle is equal to or more than 30degrees.(Senington,2017)	Mixed-on	Quadratus Lumborum: Thequadratus lumborummuscles are located in thelower back, and they assistin lateral flexion andstabilization of the spine.They play a role inmaintaining proper postureand providingstabilityduringthebowling action.
Hip-shoulderSeparation	Hipshoulder separationangle lessthan 30degree atbackfootcontact.	Intermediate	Extension	A less effective transmissionof energy from the lowerbody to the upper body maybe the outcome of a smallerhip-shoulder separationangle. (Burnett, Elliot, &Marshall, 1995). It mightmake it more difficult toproduce the torque androtational speed needed tocarry out these kinds ofoperations to their fullestpotential (P.J.Felton,2003).	Front-on	Erector Spinae: The erectorspinae muscles, includingthe iliocostalis,longissimus, and spinalismuscles, are engaged tomaintain an upright postureand stabilize the spineduring the bowling action.These muscles areresponsible for trunkextensionandhelp generate power from thelower back.
Hip-shoulderSeparation	Hip-shouldersep arationangle lessthan 30degree atback footcontact.	Low	Flexion	Depending on the specificmethod or style used, anarrower hip-shoulderseparation angle may bedesired or appreciated insome sports. For instance, amore compact or linkedrotation may be used inspecific baseball or golfswings, resulting in a reducedseparationangle. (Bell,1992)	Sideon	Obliques: The obliquemuscles, including theexternal and internalobliques, play a crucial rolein trunk rotation and lateralflexion. In a side-onbowling style, thesemuscles are heavilyengaged to generaterotational force and maintainstabilityduringthe bowlingaction.

CounterRotation	Shouldercou nter-rotationequa l to orgreater than30degre es.	High	lexion	a considerable rotation ortwisting of the shoulderswhilerotatingint heoppositedirection of the hips. Whenperforming sportsmanoeuvres like baseballpitching, throwing, or golfstrokes, this counter-rotationis frequently linked to theproduction of power andtorque(Carljpython,2016).	Mixed on	Rectus Abdominis: Therectus abdominis assists incounter rotation bycontracting to initiate andcontrol the movement ofthe upper body duringmixed style bowling. Itcontributes to trunk flexionand aids in generating powerduring the delivery.
CounterRotation	Shouldercou nterrotation lessthan 30degree.	Intermediate	Extension	It implies that during arotating movement, there islittle space between theshoulders and hips. A morelinked or compact rotationalapproach, where theshoulders and hips movetogether rather of rotating indifferent directions, may beindicated by a smallershoulder counter-rotationangle. (Ranson C. &.,2008)	Fronton	Erector Spinae: The erectorspinae muscles, includingthe iliocostalis, longissimus, and spinalismuscles, are engaged tomaintain an upright postureand stability in the lowerback throughout thebowling action. Thesemuscles provide support tothe spine and help generatepower during thedelivery.
Counterrotation	Shouldercou nterrotation lessthan 30degree	Low	Flexion	Because it allows for a moreeffective transfer of energyfrom the lower body to theupper body, a substantialshoulder counter-rotation ispreferred. The distancebetween the shoulders andhips creates a whip-likeaction that accelerates andamplifies the rotatingmovement. (Pain,2016)	Sideon	Gluteal Muscles: Thegluteal muscles, includingthe gluteus maximus,Medius, and minimus,contribute to the counterrotation by engaging and generating power from thelower body. These musclesassist in stabilizing the hipsand transferring forcebetween the lower andupper body.
ShoulderSegment atback feet	Shoulderseg mentanglegr eater than240 degrees atback footcontact	Intermediate	Extension	The angle formed by theupper arm (humerus) and thetrunk or torso during acertain action is commonlyreferred to as the shouldersegment angle. As itmeasures the departure fromthe anatomical position, therange of motion for theshoulder segment angle isnormally constrained to arange of 0 to 180 degrees. (Carljpython,2016)	Fronton	Trunk Stability: The trunkplays a crucial role inproviding stability andmaintaining an uprightposture during the delivery.The muscles of the erectorspinae, rectus abdominis,and transverse abdominisare engaged to keep thespine aligned and to resistany lateral or rotationalforces that may occurduring the action. Of trunkflexion

The results of the multiple comparisons indicate that there is a significant difference between theside on, front on, side on and mixed on, and front on mixed on group when comparing the angle ofthepelvis tothe angle ofthe shoulder.

DISCUSSION

Training Optimization:

The findings from the biomechanical analysis guide towards development oftraining programs tailored to individual bowlers. Coaches and trainers should prescribe specificexercises, drills, and intervention stoo ptimize technique,improveefficiency,andenhanceperformance based on identified strengths and weaknesses. This may involve adjustments to bodypositioning,armaction, run-up, follow-through,or othertechnicalaspects.

InjuryRiskAssessment:_

ThepresentstudyonBiomechanicalanalysisidentifiedfactorsthatcontributetoinjuryriskinfastbowlers.By examining the loadsandstressesexperiencedbydifferentbodyregionsduringthebowlingaction,potentialinjury-prone are as were identified.Coaches and trainers can be facilitated towards implement injury prevention strategies throughtargeted strength and conditioning exercises, workload management, and technique modifications toreducethe risk of injuries.

Astheroleofthefrontlowerlimbduringthefrontfootcontactphasehasimplicatedasamechanistic factor in the development of lower back injury(Manson, Weissensteiner, & Spence,1989)andfasterballspeeds(Burden,&Bartlett,,1990), weusedaclassificationcriteriontodifferentiate between styles of front lower limb actions during the front foot contact phase, definedasfull foot contactto ball release.The criteria were:

Flexor:kneeflexion10 degree ormore followed byless than10 degree ofknee extension.

Flexor-extender:flexionandextension ofof theknee by10 degreeor more

*Extender:*kneeflexion lessthan 10degree followedbyknee extensionby 10degreeormore.

Constantbrace: both flexionand extension ofthe knee lessthan10 degree.

CONCLUSIONS

Analysis of various bowling action allows assessment of the effectiveness of training interventionsandprovides valuable feedback to both coaches and bowlers.

Overall, analysis of fast bowlers with different bowling actions can offer valuable insights into optimizingtraining program sandminimizinginjur yrisk.Byunderstandingthebiomechanic alfactorsthatinfluenceperformanceandinjury,coachesandath letescanmakeevidence-baseddecisionstoimprove technique,enhanceperformance, andpromotelong-termathleticdevelopment.

1. Whencomparedto sideandfrontonbowlingstyles, mixedonbowlingmotionsignificantlydeviatesfromthe normby causingthe spineto bend laterallyexcessively.
2. Itisadvisabletoswitchfromthemixed-on bowling actiontotheside-onorfront-onbowlingaction, bothofwhich have a low risk ofspinal injury whilebowling fast or medium.
3. Thebowlers'activebowlingtimewill beextended, andearlytirednessofthesupportingtrunkmusclescanbe avoided because of the proper mechanicsand muscles' reduced stress.
4. Itissuggestedtoavoidthe mixedonbowling stylesince thesideonactionislessharmfulthanthe frontonaction.

REFERENCES

1. Bell, P. (1992). Principles of prevention and a survey of awareness among. British Journal of SportMedicine,26(4):273-275.
2. Burden,,A., &Bartlett,,R.(1990). Akinematic investigationof elitefast andfast mediumcricketbowlers.International Symposium ofthe Societyof Biomechanicsin Sports, 41-46.
3. Burnett,A.,Elliot, B.,&Marshall,R.(1995). Theeffect ofa12 overspell onfastbowlingtechniqueincricket incricket.Journal of SportsSciences, 13:329-341.
4. Carlj python,R. M.(2016). BIOMECHANICAL EVALUATIONOFMOVEMENT INSPORT AND
5. EXERCISE. RoutledgePublishers.
6. Davis, K., & Blanksby, B. (1976). A cinematographic analusis of fast bowling in cricket. AustralianJournalfor Health,Physical Education and Recreation, 71(suppl.)9-15.
7. Elliott, B.,Hardcastle ,P.,Burnett,A., &Foster, D.(1992). The influenceoffast bowlingandphysical factors on radiologic features in high performance young fast bowlers. sportsmedicinetraning and rehabilation, 3:113-130.
8. Foster, D., & Elliot, B. (1989). Send the stumps flying;the art of swing bowling. University ofWesternAustralia Press.
9. Foster,D.,John,D.,Elliott,B.,Ackland,T., &Fitch,K.(1989). Backinjuriestofastbowlersincricket:A prospectivestudy.BritishJournalOf Sports Medicine,23(3)150-154.
10. Gregory,P.,Batt,M.,&Kerslake,R.(2004).Comparingspondylolysis incricketersandsoccerplayers. British Journalof Sports Medicine, 737-742.
11. J,O. (n.d.).
12. Manson, B.,Weissensteiner, J., & Spence, P. (1989). Development of a model for fast bowling incricket. Australia: Australianinstituteos sport.
13. Orchard,J.,James,T.,Alcott,E.,Carter,S.,& Farhart,P. (2002). InjuriesinAustralian cricketatfirstclasslevel.Britishjournal of sports Medicine, 270-275.