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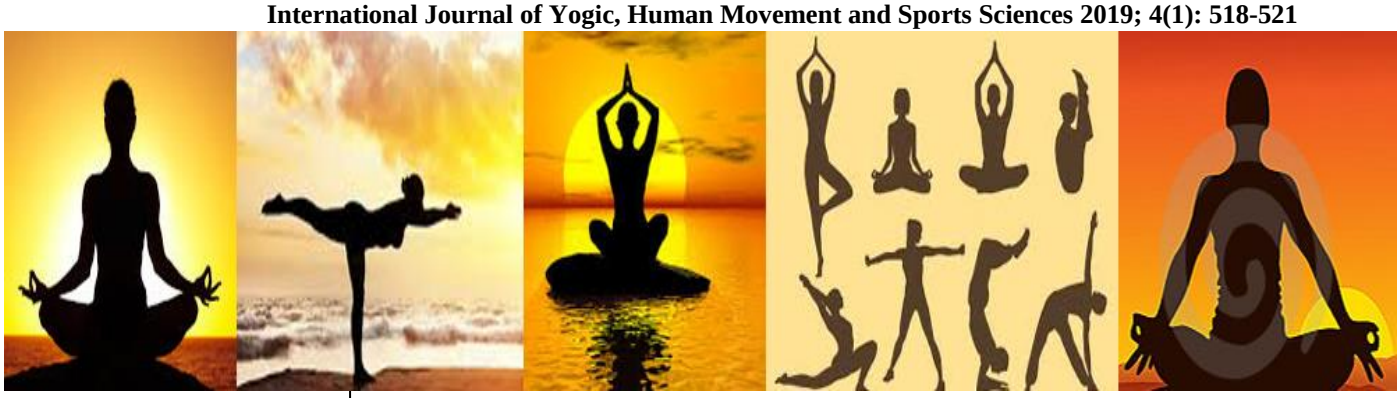

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Biomechanical analysis of low back injury among the fast medium bowlers

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Abstract
The aim of the study was to biomechanical analyse of low back injury among the fast medium bowlers. To achieve the purpose of the study 30 male cricket fast medium bowlers were selected from university /district level. Their age ranged from 18 to 25 years. They were divided in to three groups accordingly to their bowling style namely side on, front on and mixed on each consist 10 subjects. The study was determined to select the biomechanical variables. The study was formulated as true random group design 30 subjects. The groups include 30 fast medium bowlers as three types fast medium bowlers like front on, side on and mixed on style bowling. Each participants were asked to bowl three time with their own skills which were recorded by that were video recorded with on camera positioned 8 meter perpendicular to the plane of action. Data were collected by analyzing the video recording of each bowling action. Data processing was performed using the KINOVEA motion analysis software. Collected data were analysed with ANOVA was tested at 5% level of significance and Post hoc Scheffe's test was used. It was concluded that mixed on bowling action had a higher lower back injury potential than side on and front action.

Keywords: Biomechanics, injury, side on, front on, mixed on

Introduction
The fast bowler is a very important member of the team and can sometimes win the game single handely for his team. At the same time, they are on who are most prone to injury current literature evidence suggest that specific bowling techniques pose a higher risk of a lumbar vertebral stress injury**.** Fast bowling is a dynamic activity requiring bowlers to run-up and repeatedly delivers the ball at high speeds. Ball release speed is a major contributor to fast bowling success as it reduces the time the batsman has to interpret the path of the ball and make decisions regarding which shot to play. In international matches, bowlers may perform as many as 180 deliveries a day. Although cricket is generally considered a low-injury sport, fast bowlers have injury rates comparable to contact sports such as Australian Rules football and the Rugby football codes (Orchard *et al.*, 2006) [12]. Lower back injury is the most prevalent injury among fast bowlers, with lumbar stress fractures which occur predominantly on the non-dominant (non-bowling arm) side accounting for the most lost training and playing time (Gregory *et al.*, 2004) [11].
The fast bowling action can be classified as side-on, front-on, semi-front-on or mixed depending on the orientation of the shoulder hip axes and back foot alignment during delivery. Bowlers who use the side-on and front-on techniques are not at as much risk of injury as those who use the mixed technique. The semi-front-on action is a new technique that is based on the same principles as the two `safe actions', where the alignment of the shoulders and hips are in the same direction. A combination of these factors has been linked to an increased incidence of radiological features in the thoracolumbar spine, including spondylolysis, inter-vertebral disc degeneration and spondylolisthesis (Foster *et al.*, 1989; Elliott *et al.*, 1992; Burnett *et al.*, 1996) [9, 7, 5]. Spondylolisthesis was reported in50% of A-grade fast bowlers over a period of 5 years by Payne *et al.* (1987) and has been found to represent 45% of bony abnormalities reported by retired, elite fast bowlers (Annear *et al.*, 1992).
Elliott *et al.* (1992) [7] suggested that a possible reason for the high incidence of injuries amongst bowlers was that they were being forced to train longer, harder and earlier in life to

excel in their chosen sport. They suggested that the sheer number of repetitious hours of practice might produce gradual deterioration in specific parts of the body. It is therefore not surprising that physicians are diagnosing an increased number of overuse injuries. Bell (1992) [2] stated that the combination of incorrect technique, poor preparation, overuse and clinical features all increased the risk of injury to the bowler. For an impact sport, this means large forces are transmitted through a variety of body tissues via the foot, ankle, knee, hip and various joints of the back. Often concurrently with these high loads, the trunk is flexing laterally and rotating in an effort to maximize the speed of the bowling-shoulder. A range of mechanical variables have been commonly linked with lower back injury and include, but are not delimited to: shoulder alignment counter rotation (CR), hip-shoulder alignment separation angle (SA), front knee flexion (KF) and trunk lateral flexion (TLF) (Foster *et al.*, 1989; Burnett *et al.*, 1995; Ranson *et al.*, 2005) [9, 5].

Ranson *et al.* (2008) [14] proposed that concurrent lower trunk extension, ipsilateral rotation and extreme contralateral side-flexion during the early part of the front foot contact phase of the bowling action may be an important mechanical factor in the aetiology of this type of injury. However, they highlighted the need for further prospective and mechanical modelling studies to determine the relationship 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 *et al.* (1995) [5] found that bowlers using the mixed action, in addition to having a large amount of trunk twisting occurring during the shoulder counter-rotation, also had more twist at release (greater pelvis-shoulder separation angle). This is of some concern as the trunk becomes increasingly flexed after release. Pearcy (1993; as cited by Burnett *et al.*, 1995) [5] suggested that there may be a mechanism for increased vulnerability of the posterior annulus to injury when twisting is combined with flexion.

Material and Methods

The study sample comprised 30 male cricket fast medium bowlers (10 bowlers performing side on bowling style, 10 bowlers performing front on bowling style and 10 bowlers performing mixed on bowling style) were selected who play at the university level and district level, their age ranged between 18 and 25 years and they were divided into three groups to their bowling style namely side on, front on and mixed on each consist of 10 subjects. The study was delimited to low back injury among the fast medium bowlers and selected biomechanical parameters such as shoulder alignment with vertical line, hip alignment with vertical line, difference between angle of pelvis to the angle of shoulder and hip to shoulder angle. The study was formulated as true random design with 30 subjects. Each subject performed three trails bowling action with dominant.

Videography Procedure

The selected variables namely shoulder alignment with vertical line, hip alignment with vertical line, difference between angle of pelvis to the angle of shoulder and hip to shoulder angle were assessed by video capturing technique. Investigator was used the capturing technique videos capture Sony HD camera. In this study, the camera was used to capture the bowling action of the bowlers. The camera was placed perpendicular to the action place at a distance of 8 meters to capture the bowling action. A Sony camera was used to record the trials at 65 frames per second. The camera was mounted on a tripod at height of 1. 30 m from the ground level. It was placed at a distance of 8 meters from the plane of action. Subjects were asked to dress in minimal attire as to avoid any ambiguity markers were fixed on acromial process of both the shoulders and posterior superior iliac spine of pelvic bone. The camera was placed parallel to popping crease and facing the posterior side of the bowler. Each subject asked to bowl three times and at the moment of ball release images are captured on Posterior-Anterior view. The recorded video uploaded to computer in which the video is analyzed using Kinovea motion analysis software and selected variables were measured in degrees. The hip alignment was measure from angle between the positions of pelvis to vertical line through help of protractor tool in the software. The shoulder alignment was measured the angle between the position of shoulder to vertical line with help of protractor tool in the software. Hip to shoulder alignment angle was measured between the positions of shoulder to position of hip help of protractor tool in the software.

Statistical Analysis

Collected data were statistically analysed by the application of analysis of variance (ANOVA) and whenever the 'f' ratio was significant it is analysed through post hoc test for inter group difference.

Research and Discussion

Table 1: Results on hip to shoulder angle

	Mean	Sov.	Df	Sum of square	Mean sum of square	F value
Side on	23					
Front on	35.2	B	2	4179.47	2089.73	149.58*
Mixed on	51.8					
		W	27	377.2	13.97	
		T	29	4556.66		

Significant at 0.05 as well as 0.01.

(The table value required for significant at 0.05 level of confidence with df 2 and 27 is 3.35) The table I shows that mean values of three groups on Hip to shoulder are 23, 35.2 and 51.8 respectively. The obtained 'F'ratio 149.58 is greater than required value 3.35 for significance, hence it is said to be at 0.05 at level.

The result of the study indicates that there was a significant difference among the fast medium bowlers on Hip to shoulder angle. Since the obtained F ratio hip to shoulder was significant scheffe's post hoc test applied as post hoc test to determine which of the paired mean have significant difference.

Table 1A: Scheffe's post hoc test on hip to shoulder angle

Group I	Group II	Group III	M D	C D
23	35.2		-12.2	4.32
23		51.8	-28.8	
	35.2	51.8	-16.6	

*significant at0.05 level.

The multiple mean comparison shows that there existed significant difference between side on and front on and mixed on and front on mixed on group on hip to shoulder angle are statistically significant.

Table 2: Results on shoulder alignment with vertical line

	Mean	SOV	Df	Sum of square	Mean sum of square	F value
Side on	42.7					
Front on	38.7	B	2	6120.06	3060.03	137.56
Mixed on	10.6					
		W	27	600.6	22.24	
		T	29	6720.66		

*****Significant at 0.05 as well as 0.01.

(Table value required for significant at 0.05 level of confidence with df 2 and 27 is 3.35) The table value II shows that mean values of three groups on shoulder alignment with vertical line are 42.7, 38.7 and 10.6 respectively. The obtained 'F' ration 137.56 which is greater table value 3.35 for significance, hence it is said to be significant at 0.05 level. The result of the study indicates that there was a significant difference among the fast medium bowlers on shoulder alignment with vertical line.

Since the obtain f ration on shoulder alignment with vertical line was significant, scheffe's post hoc test was applied as post hoc test to determine which of the paired mean have significant difference.

Table 2A: Scheffe's post hoc test on shoulder alignment with vertical line

Group I	Group II	Group III	M D	C D
42.7	38.7		4	5.46
42.7		10.6	32.1	
	38.7	10.6	28.1	

*significant at 0.05 level

The multiple mean comparison shows that there existed significant difference between side on and mixed on and front on and mixed on group on shoulder alignment with vertical line are statistically significant and there was no significant difference between side on and front on groups.

Table 3: Results on hip alignment with vertical line

	Mean	SOV	Df	Sum of square	Mean sum of square	F value
Side on	71.6					
Front on	68.2	B	2	403.4	201.7	12.48*
Mixed on	62.7					
		W	27	436.1	16.15	
		T	29	839.5		

*Significant at 0.05 as well as 0.01.

(The table value required for significant at 0.05 level of confidence with df 2 and 27 is 3.35)

The table value III shows that the mean values of three groups on hip alignment with vertical line are 71.6, 68.2 and 62.7 respectively. The obtained 'F' ration 12.48 which is greater than the required table value 3.35 for significant, hence it is said to be significant at 0.05 level.

The result of the study indicates there was a significant difference among the fast medium bowlers on hip alignment with vertical line.

Since the obtained f ratio on hip alignment with vertical line was significant scheffe's post hoc test was applied as pos hoc test to determine which of the paired mean have significant difference.

Table 3A: Scheffe's post hoc test on hip alignment with vertical

Group I	Group II	Group III	M D	C D
71.6	68.2		-3.4	4.65
71.6		62.7	5.5	
	68.2	62.7	8.9	

*significant at 0.05 level

The multiple mean comparison shows that there existed significant difference between side on and mixed on, and front on mixed on group on hip alignment with vertical line are statistically and there existed on significant difference between side on and front on.

Table 4: Results on difference between angle of pelvis to the angle of shoulder

	Mean	SOV	Df	Sum of square	Mean sum of square	F value
Side on	-25.5					
Front on	.32.9	B	2	3769.86	1884.93	49.58
Mixed on	-52.1					
		W	27	1026.3	38.01	
		T	29	4796.16		

*significant at 0.05 as well as 0.01.

(The table value required for significant at 0.05 level of confidence with df 2 and 27 is 3.35) The table value IV shows that the mean values of three groups on difference between the pelvis to angle of shoulder are 25.5, 32.9 and 52.1 respectively. The obtained 'F' ration 49.58 which is greater than the required table value 3.35 for significances, hence it is said to be significant at 0.05 level.

The result of the study indicates that there was significant difference among the fast medium bowlers on difference angles of pelvis to the angles of shoulder.

Since obtained F ration on difference between angle of pelvis to the angle of shoulder was significant, scheffe's post hoc test was applied as post hoc test to determine which of the paired mean have significant difference.

Table 4A: Scheffe's post hoc test on difference between angle of pelvis to the angle of shoulder

Group I	Group II	Group III	M D	C D
-25.5	-32.9		7.4	7.14
-25.5		-52.1	26.6	
	-32.9	-52.1	19.2	

*significant at 0.05 level

The multiple mean comparisons shows that there existed significant difference between side on and front on and side on and mixed on and front on mixed on group on angle of pelvis to the angle of shoulder are statistically significant.

Discussion

From the above obtained data it is clearly proved that mixed on bowling actions is highly from the normal range that is the spine is laterally bending excessively comparing with the side on and front on bowling action. As discussed previously that the injury incidence will be more when the spine laterally flexed and rotated causes the early degenerative changes in the lumbar spine, as well the injury to the spinal musculature, and due to this excessive lateral flexion and rotation: huge stress will be placed on intervertebral disc. As in the case of

side on bowling there is acceptable level by the front on bowling style. So it is advisable to change the bowling action from the mixed on bowling style preferably to side on action and front on action both in which the minimal risk of injuring the spine during the fast medium bowling. By reducing the risk of injury, the active bowling period of the bowlers will be prolonged and due to the correct mechanics the muscles will be put under less stress and early fatigue of the supporting trunk muscles can be reduced. Hence it is obvious that the side on bowling style is less injuring nature followed by front on action so it is advisable to avoid the mixed on bowling style.

Conclusions

1. Mixed on bowling action is highly deviating from the normal range that is spine is laterally bending excessively comparing with side and front on bowling style.
2. It is advised to change the bowling action from the mixed on bowling style preferably to side on action an front action both in which the minimal risk of injuring the spine during the fast medium bowling.
3. The active bowling period of the bowlers will be prolonged and due to the correct mechanics and muscles will be put less stress and early fatigue of the supporting trunk muscles can be reduced.
4. The side on bowling style is less injuring nature, followed by front on action so it is advisable to avoid the mixed on bowling style

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