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ORIGINAL RESEARCH

Cricket Biomechanics Analysis of Skilled and Amateur Fast Bowling Techniques

[1]KA Thiagarajan, [2]Tvisha Parikh, [3]Anees Sayed, [4]MB Gnanavel, [5]S Arumugam

ABSTRACT

Cricket fast bowling action involves complex three-dimensional (3D) motion of the body and poses a high risk of injury more so in schoolboys. It is not known how the bowling technique varies between skilled and less skilled fast bowlers. The aim of this study is to compare the differences in bowling technique between young sub-elite (skilled) and amateur university level cricketers. Twelve players, 6 skilled and six amateur, were attached with 35 retro-reflective markers using the full body Plug-in-Gait marker set and asked to bowl 6 deliveries at a good length. Their bowling action was captured with 12 Vicon 3D cameras and the ground reaction force was measured using AMTI force plates. The best delivery from each bowler was selected. Their bowling action types were classified and parameters like shoulder counter rotation (SCR), pelvic-shoulder separation angle at back foot contact, trunk lateral flexion, front knee angle, front foot vertical ground reaction force (vGRF) and ball release speed were measured. The results were analyzed with Levene's test for Equality of Variances and a t-test for equality of means. The skilled bowlers showed faster ball release speed and experienced larger vGRF while the other parameters did not show any significant differences.

Keywords: Amateur, Biomechanics, Cricket.

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INTRODUCTION

The game of cricket is undoubtedly the most popular sport in India. The fast bowler is a very important member of the team and can sometimes win the game single-handedly for his team. At the same time, they are the one who are most prone to injuries.[1] Current literature evidence suggests that specific bowling techniques pose a higher risk of a lumbar vertebral stress injury.[8] But it is difficult for a coach to detect the various biomechanical factors using the naked eye alone.[7]

The fast bowling action involves complex three-dimensional (3D) motion of the trunk, upper limb and lower limb as the bowler attempts to produce maximum ball velocity.[2] During the final delivery stride, fast bowlers experience vertical ground reaction forces of up to three times their body weight at back foot contact[16] and nine times body weight at front foot contact.[12,17]

Cricket Biomechanics

Biomechanics deals with movement and forces during the movements, and the objective capture, measurement and analysis of 3D human movement is a keystone of Sports Biomechanics. Sports biomechanical research into the fast bowling action has a number of studies on the relationships between technique and injury.[4-6] Current motion analysis technologies offer accurate and reliable measurement of 3D joint motion, and have helped in developing screening and intervention methods in sports.[1] Examples of three dimensional motion capture can be seen in Figures 1 and 2.

Bowling Action Types

The fast bowling action starts during the delivery stride prior to ball release. The first key event during the delivery stride is back foot contact (BFC) when the bowler's back foot impacts the ground. This is followed by front-foot contact (FFC) after that ball release. Fast bowling actions can be broadly categorized into one of four action types: Front-on, Side-on, Semi-open and mixed. This is determined according to the alignment of the two shoulders at BFC and the amount of shoulder counter-rotation during the delivery stride. Shoulder counter rotation is defined as the change in the shoulder alignment angle from a relatively front-on alignment at BFC to the most side-on shoulder alignment during the delivery stride (Minimum Shoulder Angle).[9] Classification of bowling is based upon the studies by Bartlett et al (1996) and Portus et al (2004).[2,4] The four bowling action types are shown in Figure 3 and explained in the following pages.

[1]Assistant Professor, [2]Sports Physician and Senior Resident
[3]Sports Biomechanist and Tutor, [4]Sports Biomechanist
[5]Senior Consultant, Professor and Head

[1-5]Department of Arthroscopy and Sports Medicine, Sri Ramachandra Medical College, Chennai, Tamil Nadu, India

Corresponding Author: KA Thiagarajan, Assistant Professor Department of Arthroscopy and Sports Medicine, Sri Ramachandra Medical College, Chennai, Tamil Nadu, India Phone: 9444415744, e-mail: drkatn@srassc.in

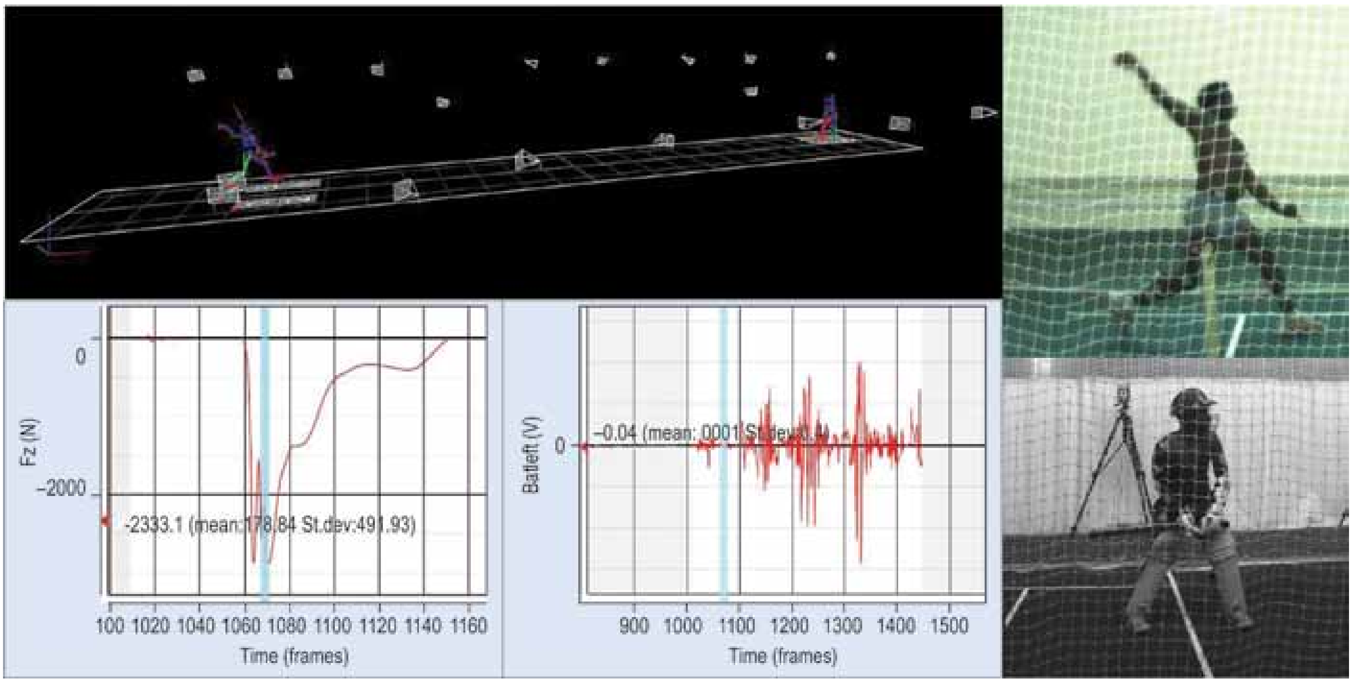


Fig. 1: Estimation of vertical ground reaction forces (vGRF) of the bowler F_z(N)

Side-on action is characterized by a low run up speed, rear-foot positioned parallel with the crease, and a shoulder alignment at rear-foot strike that points down the wicket toward the batsman at approximately 180° (shoulder segment angle).[2] Side-on action defined as 'a shoulder segment angle less than 210° at back foot contact, a hip-shoulder separation angle less than 30° at back foot contact, and, shoulder counter-rotation less than 30°.[4] A key feature of a side-on delivery is that the lumbar spine is subject to less rotation when compared with other actions. The side-on action while being the most 'traditional' action is now considered to be extremely rare in modern day fast bowlers.[8]

In a front-on action, the bowler's hips and shoulders are open prior to delivery, giving the appearance of the bowler running straight toward the batter. This action is described as 'having a shoulder segment angle greater than 240° at back foot contact, a hip-shoulder separation angle less than 30° at back foot contact, and, shoulder counter-rotation less than 30°.[4] Similar to side-on action, degree of rotation is lesser when compared to other actions.

Fig. 2: The sports biomechanics lab at Sri Ramachandra Arthroscopy and Sports Sciences Centre which is the only ICC accredited facility in India for cricket bowling action analysis

Semi-open action is relatively a new classification and is considered a safe technique by Australian Cricket Board.[4] In this action, the shoulder segment angle lies between the front-on and side-on actions. Similar to both the side-on and front-on actions, there is little to no counter-rotation of the shoulders. It is described as 'a shoulder segment angle from 210° to 240° at back foot contact, a hip-shoulder separation angle less than 30° at back foot contact, and, shoulder counter-rotation less than 30°.[4,8]

Mixed action is a combination of both side-on and front-on bowling actions. The mixed action is defined as any action with 'a hip-shoulder separation angle equal to or greater than 30° at back foot contact, or, shoulder counter-rotation equal to or greater than 30°.[4] The mixed action has been found in numerous studies to be strongly associated with the development of lumbar vertebral stress injuries, whereas there is no evidence for an increased risk of injury with front-on and semi-open actions, most likely due to the lower levels of counter-rotation associated with this bowling style.[8]

Lateral Trunk Flexion

In a fast bowling action, large impact forces are transferred through the kinetic chain from the foot to ankle to knee joint to hip joint to lumbar spine. Earlier shoulder counter-rotation was considered as the component of the

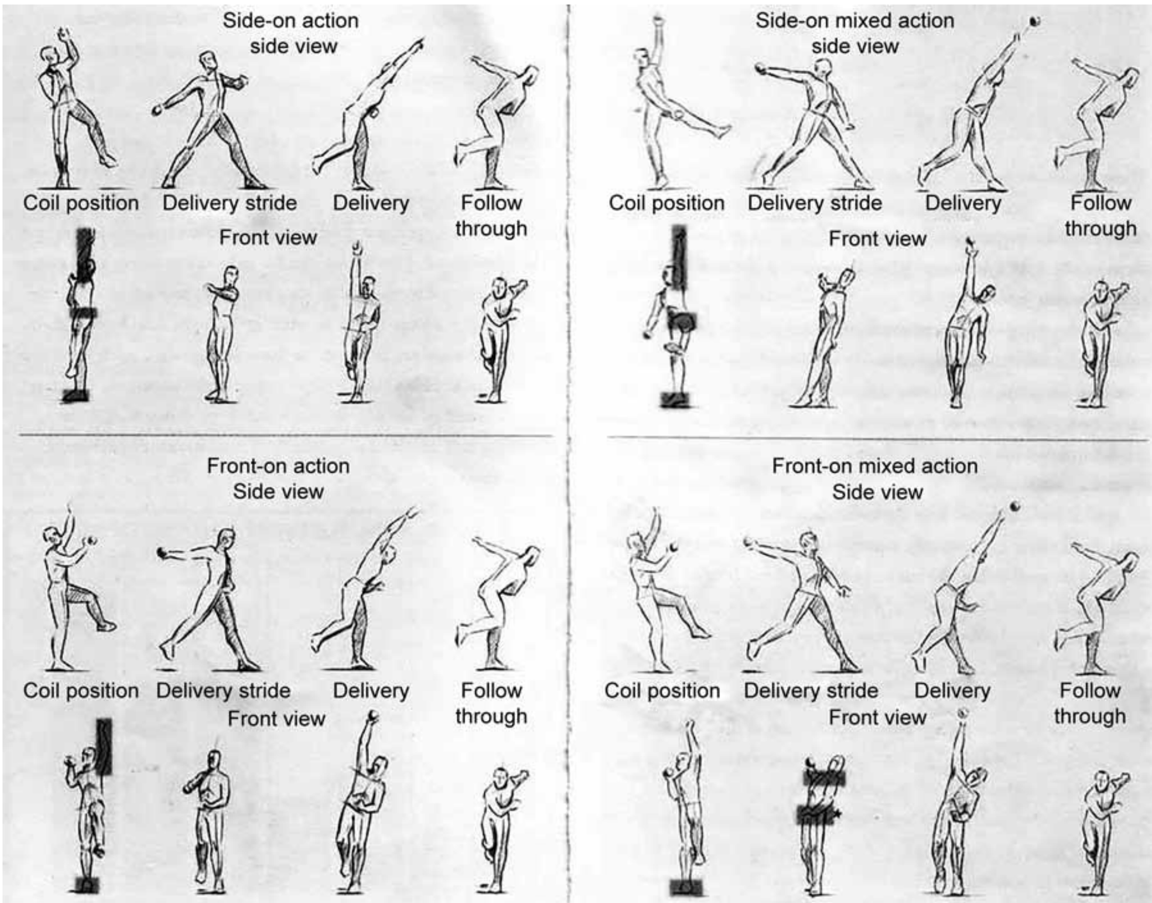


Fig. 3: Depiction of various types of cricket bowling actions

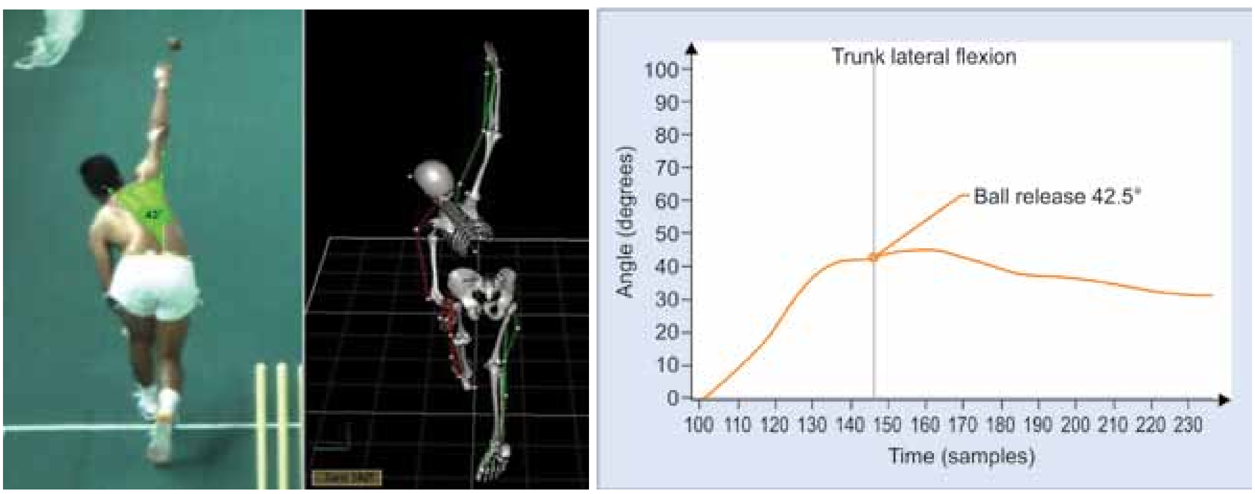


Fig. 4: Estimation of trunk lateral flexion angle by 2D video and 3D motion capture analysis

bowling action that has been most consistently associated with lumbar injury in fast bowlers.[6] Recent studies have started showing that not only shoulder counter rotation but increased contralateral trunk flexion and ground reaction force also acts as a stressor on lumbar spine.[6,9,14]

Position of extreme contralateral lower trunk lateral flexion, in combination with large ground reaction forces during front foot contact phase, is the most significant stressor of the contralateral side lumbar pars interarticularis.[9,10] Injured bowlers were shown to be more late-rally flexed during the delivery stride and experienced greater peak lumbo-pelvic lateral flexion moments than bowlers who did not suffer a low back injury.[11] Fast bowlers who are more laterally flexed, experience greater lumbar loads during bowling, have reduced back extensor muscle endurance, and demonstrate impaired control of the lumbo-pelvic hip complex, are at increased risk of low back injury.[11] Figure 4 shows the lateral flexion of the bowler at ball release.

Front Knee Angle

The front lower limb during the front foot contact phase has been implicated as a mechanistic factor in the development of lower back injury.[4,12,13] Portus et al in 2004, used a classification criterion to differentiate between styles of front lower limb actions during the front foot contact phase, defined as full foot contact to ball release. The criteria were:

Flexor: Knee flexion 10° or more followed by less than 10° of knee extension.

Flexor-extender: Flexion and extension of the knee by 10° or more.

Extender: Knee flexion less than 10° followed by knee extension by 10° or more.

Constant brace: Both flexion and extension of the knee less than 10°.

The front leg acts as a shock absorber to attenuate the ground reaction forces upon front foot contact. The front knee flexion angle has strong correlations with both the lumbar spine rotation and lateral bending moments and, therefore, has an important effect on lumbar spine loading.[14] The 'optimum' front leg action is considered to be one that lands extended or slightly flexed, followed by a period of flexion to absorb shock, before vigorously extending up to the point of ball release to provide an effective lever for the upper body to rotate around.[15]

Bowlers who had a more extended front knee when releasing the ball, as opposed to those who had a more flexed front knee at this time, tended to experience higher braking and vertical impact forces.[4] A more extended front knee during the front foot contact phase has been associated with spondylolysis development.[4,13] Figures 5 and 6 show the bowler's front knee flexion being monitored from front foot contact to ball release.

Fig. 5: Front knee angle in 2D video and 3D motion capture analysis

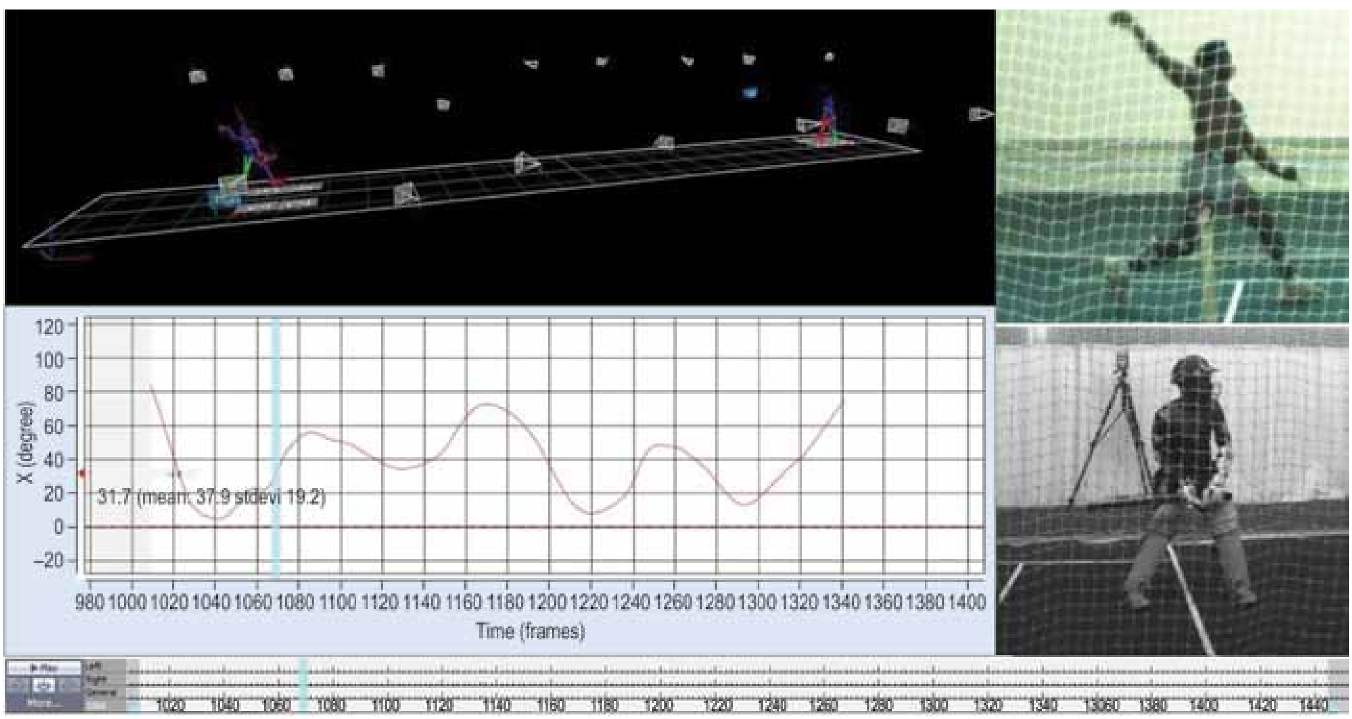


Fig. 6: Estimation of front knee angle of the bowler by 3D motion capture analysis

Cricket Injury Prevalence in the Young

Epidemiological studies have shown that fast bowlers are at most risk of injury among schoolboys (47.4%) and A-grade or provincial cricketers (42%).[3] Cricket fast bowling involves complex body mechanics with the bowlers implementing their skills and technique to get the better of the opposition batsmen. Like most sports, cricket is played by bowlers of various skill levels and over all the age groups. At a regional level, the player selection trials aim to select players from the pool of amateur cricketers, where the selectors have the daunting task of identifying players based on talent and skill. A skilled fast bowler is expected to get more wickets than lesser skilled bowlers. Skilled bowlers are also expected to consistently be able to control where they want to land the ball without considerably dropping their pace. However, it is not known how the bowling technique varies between skilled and less skilled fast bowlers. If significant differences can be found between the bowling biomechanics factors between skilled and less skilled cricketers, then biomechanics could become a useful tool for talent screening and talent identification.

AIMS

The aim of this study is to compare the differences in bowling technique between young sub-elite (skilled) players and amateur university level cricketers.

METHODS

Twelve players were recruited for this study, out of which six were skilled fast bowlers, who played at regional sub-elite level, were part of a coaching program and trained more than three times a week, along with six amateur cricketers, who were not receiving coaching and trained less than thrice a week. The fast bowlers were between the ages of 16 to 25. The bowlers were attached with 35 retroreflective markers using the fullbody Plug-in-Gait marker set (Fig. 7) and the two 1 inch retroreflective tape squares were placed on to ball to measure ball release speed. These bowlers were then asked to ball six deliveries (Figs 2 and 8) at a good length while their bowling action was being captured with 12 Vicon 3D cameras and the ground reaction force was measured using an AMTI force plate. The best delivery from each bowler was selected for this study, by the bowler and the biomechanists. The 3D data processing was carried out using the Plug-in-Gait on Vicon Nexus software. The biomechanics parameters being calculated were bowling action classification, shoulder counter rotation (SCR), pelvic-shoulder separation angle at back foot contact, trunk lateral flexion, front knee angle, front foot vertical ground reaction force (vGRF) and the ball release speed. Some of these parameters are shown in Figures 4 to 6 and 9 to 11.

Fig. 7: Marker placement on the bowler for 3D motion capture

Fig. 8: Three-dimensional motion capture of the bowler in action at the lab

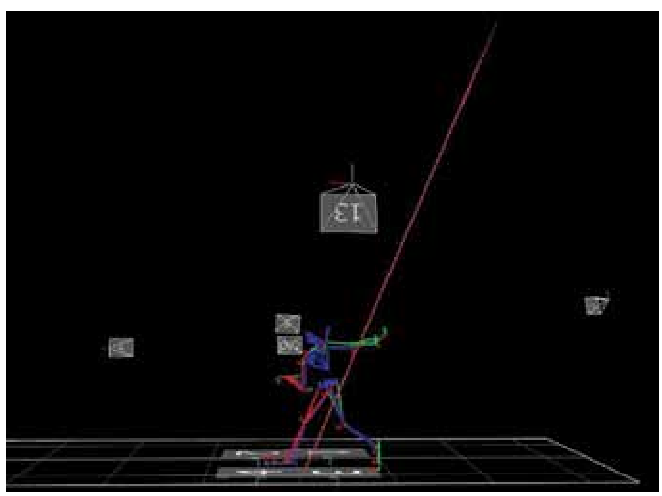


Fig. 9: Estimation of the vertical ground reaction forces vGRF

RESULTS

The results were analyzed with Levene's test for equality of variances and a t-test for equality of means as shown in Tables 1 and 2. The p-value has been highlighted in Table 2. The Box plots shown in Graphs 1 to 6, compare the means and standard deviation for the 7 parameters being tested. The skilled bowlers had faster ball release speed and experienced larger vGRF (normalized to bodyweights) than amateur fast bowlers. The other biomechanical parameters did not show any significant differences between the two population groups.

DISCUSSION AND CONCLUSION

Although the skilled bowlers were more trained and played more competition than the amateur bowlers, the biomechanical factors of a single delivery alone was not

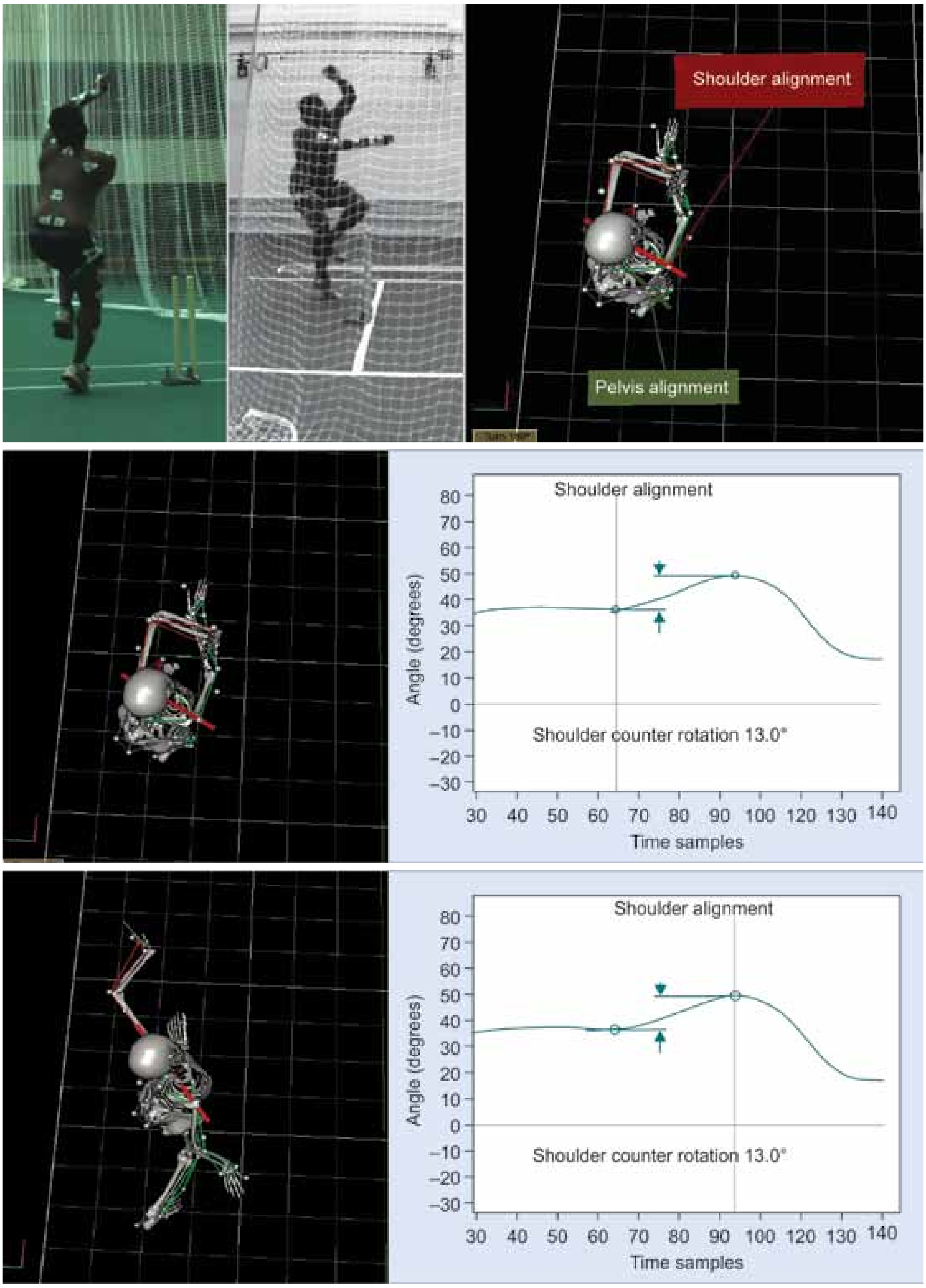


Fig. 10: Estimation of the SCR

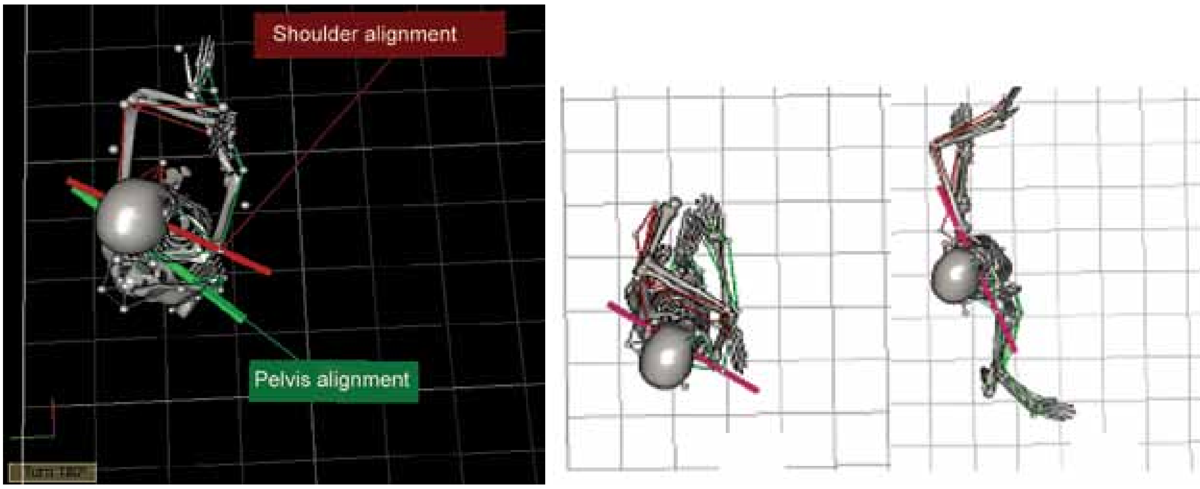


Fig. 11: Estimation of the pelvis shoulder separation

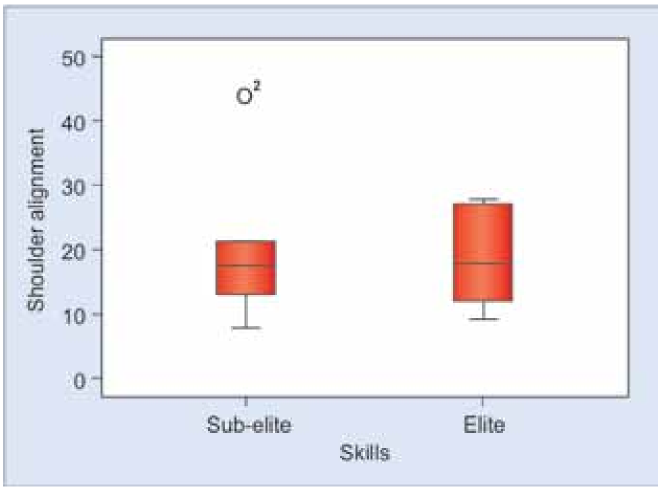
Table 1: Statistical analysis of the results of the Biomechanics parameters

Group statistics					
	Skills	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Shoulder alignment	Sub-elite	6	20.25	12.78	5.21
	Elite	6	18.65	7.96	3.25
Pelvis shoulder separation	Sub-elite	6	9.67	3.54	1.44
	Elite	6	12.99	6.49	2.65
Trunk lateral flexion	Sub-elite	6	48.35	15.95	6.51
	Elite	6	44.75	7.60	3.14
Front knee flexion FFC	Sub-elite	6	15.70	8.74	3.57
	Elite	6	20.22	10.12	4.13
Front knee flexion ball release	Sub-elite	6	57.97	16.45	6.72
	Elite	6	43.28	20.56	8.39
Ground reaction force	Sub-elite	6	3.47	0.52	0.21
	Elite	6	5.18	1.38	0.56
Ball release speed	Sub-elite	6	99.25	6.53	2.67
	Elite	6	106.57	4.51	1.84

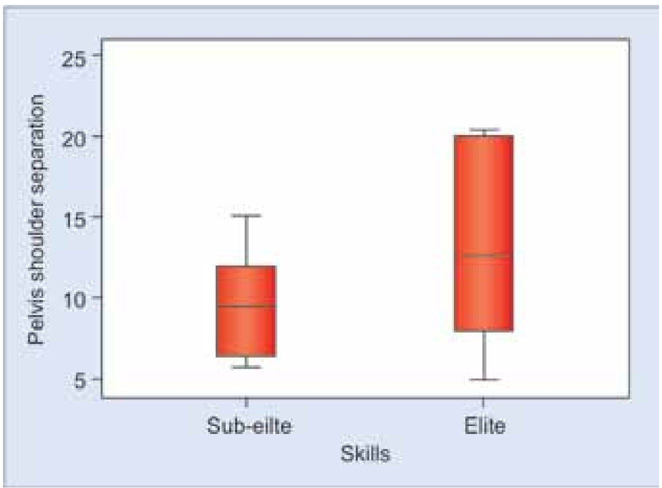
Table 2: Statistical analysis of the results showing vGRF as the significant factor in the biomechanical difference between the two groups

Independent samples test										
		Levene's test for equality of variances					*t-test for equality of means*			
									95% CI of the difference	
Biomechanics Parameter		*F*	*Sig.*	*t*	*df*	*Sig. 2 tailed*	*Mean difference*	*Std. error difference*	*Lower*	*Upper*
Shoulder alignment	E	0.162	0.696	0.260	10	**800**	1.60	6.15	– 12.09	15.29
	N			0.260	8.376	**801**	1.60	6.15	– 12.46	15.66
Pelvis shoulder Sep	E	5.484	0.041	– 1.099	10	**297**	– 3.32	3.02	– 10.03	3.40
	N			– 1.099	7.728	**305**	– 3.32	3.02	– 10.31	3.68
Trunk lateral flexion	E	3.376	0.096	0.498	10	**629**	3.60	7.23	– 12.50	19.70
	N			0.498	7.206	**633**	3.60	7.23	– 13.39	20.59
Front Knee flexion FFC	E	0.001	0.976	– 0.827	10	**427**	– 4.52	5.46	– 16.68	7.65
	N			– 0.827	9.793	**428**	– 4.52	5.46	– 16.71	7.68
Front Knee flexion @ BR	E	0.350	0.567	1.366	10	**202**	14.69	10.75	– 9.26	38.63
	N			1.366	9.542	**203**	14.68	10.75	– 9.42	38.79
Ground reaction force	E	4.046	0.072	– 2.858	10	**017**	– 1.72	0.600	– 3.05	– 0.37
	N			– 2.858	6.401	**027**	– 1.72	0.600	– 3.16	– 0.26
Ball release speed	E	1.758	0.214	– 2.260	10	**047**	– 7.32	3.24	– 14.54	– 0.10
	N			– 2.260	8.888	**051**	– 7.32	3.24	– 14.66	– 0.02

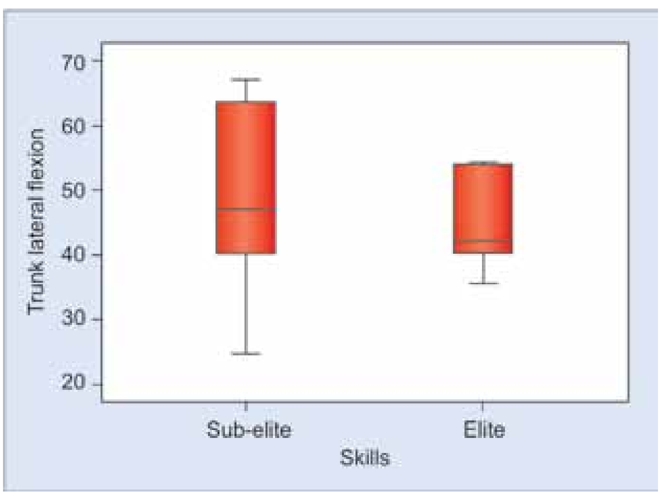
*E: Equality of variance assumed; N: Equality of variance not assumed



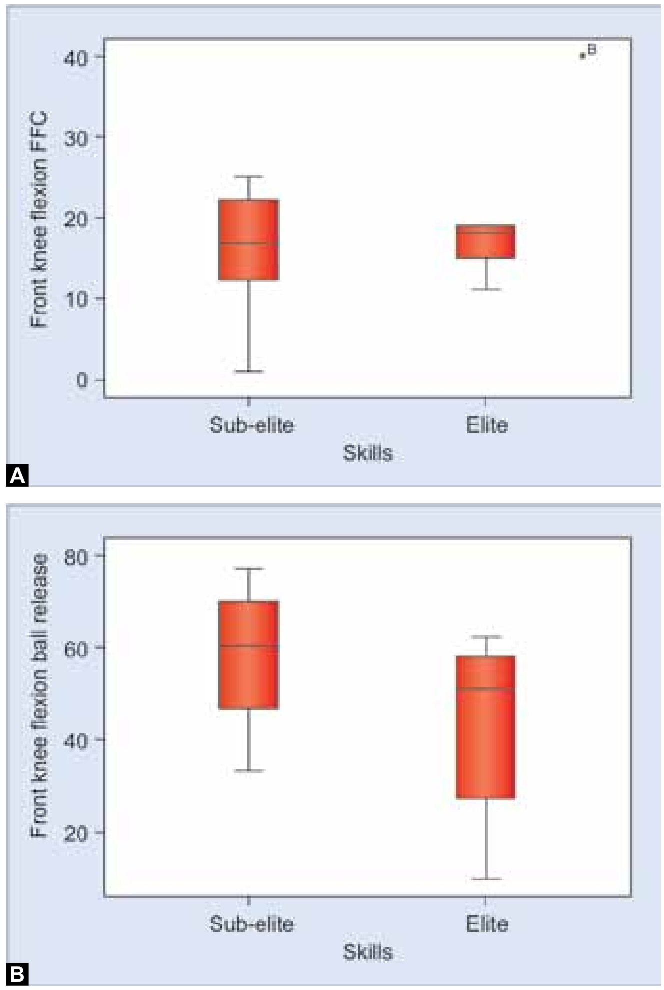
Graph 1: Shoulder alignment



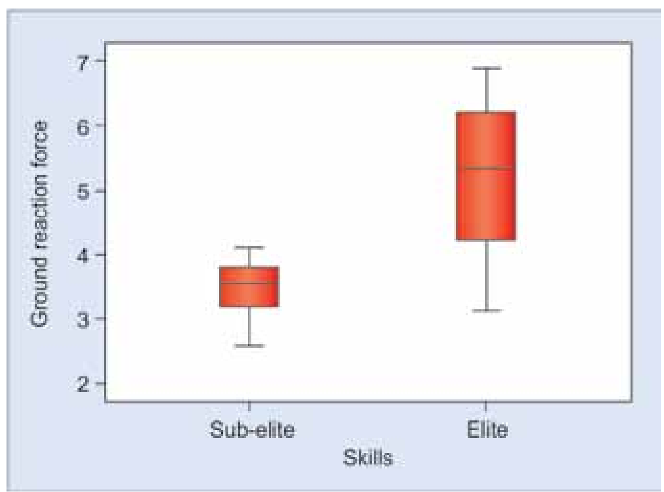
Graph 2: Pelvis shoulder separation



Graph 3: Trunk lateral flexion

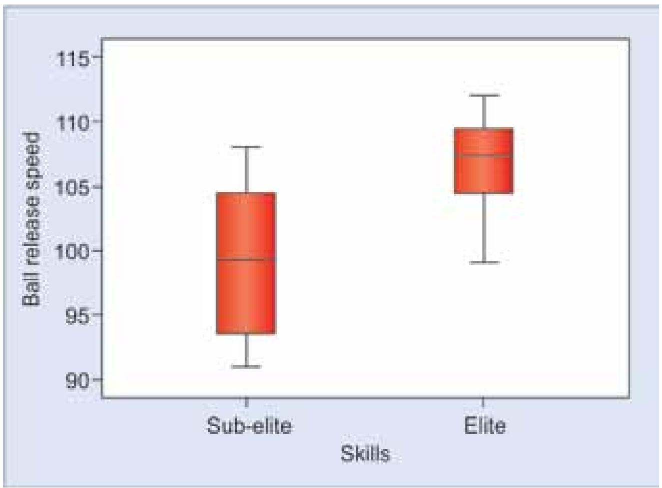


Graphs 4A and B: (A) Front knee flexion and (B) Front knee flexion at ball release



Graph 5: Vertical ground reaction force (vGRF)

able to differentiate between the two groups. Hence, the next step would entail processing the data and calculating the same biomechanical parameters for all the six deliveries bowled by the 10 players. That data will allow us to look at the variance of the biomechanical parameters between the sub-elite and amateur bowlers, which might then show significant differences between the two population groups.



Graph 6: Ball release speed

REFERENCES

1. Stretch RA. Cricket injuries: a longitudinal study of the nature of injuries to South African cricketers. Brit J Sports Med 2003;37(3):250-253.
2. Bartlett RM, Stockill NP, Elliott BC, Burnett AF. The biomechanics of fast bowling in men's cricket: a review. J Sports Sci 1996;14(5):403-424.
3. Aginsky KD, Noakes TD. Why it is difficult to detect an illegally bowled cricket delivery with either the naked eye or usual two-dimensional video analysis. Brit J Sports Med, 2010;44(6): 420-425.
4. Portus MR, Mason BR, Elliott BC, Pfitzner MC, Done RP. Cricket: technique factors related to ball release speed and trunk injuries in high performance cricket fast bowlers. Sports Biomech, 2004;3(2):263-284.
5. Elliott B, Alderson J. Laboratory versus field testing in cricket bowling: a review of current and past practice in modelling techniques. Sports Biomech, 2007;6(1):99-108.
6. Crewe H, Campbell A, Elliott B, Alderson J. Lumbo-pelvic loading during fast bowling in adolescent cricketers: the influence of bowling speed and technique. J Sports Sci, 2013;31(10):1082-1090.
7. Aginsky KD, Noakes TD. Why it is difficult to detect an illegally bowled cricket delivery with either the naked eye or usual 2D video analysis. Br J Sports Med 2008;44(6):420-425.
8. Johnson M, Ferreira M, Hush J. Lumbar vertebral stress injuries in fast bowlers: a review of prevalence and risk factors. Phys Therap Sport 2012;13(1):45-52.
9. Ranson CA, Burnett AF, King M, Patel N, O'Sullivan PB. The relationship between bowling action classification and three-dimensional lower trunk motion in fast bowlers in cricket. J Sports Sci, 2008;26(3):267-276.
10. Chosa E, Totoribe K, Tajima N. A biomechanical study of lumbar spondylolysis based on a three-dimensional finite element method. J Orthopaed Res, 2004 Jan;22.
11. Bayne H, Elliott B, Campbell A, Alderson J. Lumbar load in adolescent fast bowlers: a prospective injury study. J Sci Med Sport 2015 Mar.
12. Mason B, Weissensteiner J, Spence P. Development of a model for fast bowling in cricket. Excel 1989;6(1):2-12.
13. Foster D, John D, Elliott B, Ackland T, Fitch K. Back injuries to fast bowlers in cricket: a prospective study. Brit J Sports Med 1989;23(3):150-154.
14. Ferdinands RED, Stuelcken M, Greene A, Sinclair P, Smith R. Lumbar kinematics and kinetics of young australian fast bowlers. Int Conference on Biomech Sports 2010.
15. Glazier PS, Wheat JS. An integrated approach to the biomechanics and motor control of cricket fast bowling techniques. Sportsmed 2014 Jan;44(1):25-36.
16. Elliott BC, Hardcastle PH, Burnett AE, Foster DH. The influence of fast bowling and physical factors on radiologic features in high performance young fast bowlers. Res Sports Med: An Int J, 1992;3(2):113-130.
17. Worthington P, King M, Ranson C. Relationships between fast bowling technique and ball release speed in cricket. J Applied Biomech, 2012;29(1):78-84.