COMPARISON OF MEASUREMENT SYSTEMS USED TO DETERMINE ELBOW ANGLE DURING CRICKET BOWLING

Jason Gurney and Uwe Kersting

Biomechanics Lab, Department of Sport & Exercise Science, The University of Auckland, Auckland, New Zealand

The purpose of this study was to compare the two most popular measurement systems employed by biomechanists to determine elbow angle during cricket bowling. These systems included a Vicon marker-based motion capture system and a Biovision electrogoniometer, each synchronised and collecting data at 500Hz. Elbow angle data was calculated using each system from eight (n=8) subjects while performing cricket bowls within the Biomechanics Lab. The current study revealed that there is a significant difference between the change in elbow angle during the delivery phase calculated by an electrogoniometer to that calculated by a marker-based system. Possible reasons for this finding include crosstalk between axes in the electrogoniometer measurement system.

KEY WORDS: cricket, bowling, electrogoniometer, 3D kinematics.

INTRODUCTION: The arm action during the delivery phase of the bowling action in cricket has been reported to contribute up to 50% to the final ball release velocity obtained (Bartlett, 1996, Elliott et al., 1986). In recent years, the issue of 'throwing' in cricket has become a contentious issue. Situations such as the infamous 'no-balling' of Muttiah Muralitharan during the Boxing Day game in 1995, where he was 'no-balled' seven times in one match for throwing the ball, have been widely publicised in the press and the throwing issue has therefore grown in stature. The International Cricket Council recently altered the rules regarding this controversial issue. The specific rule in question is Rule 24.3, which defines throwing as "the process of straightening the bowling arm, whether it be partial or complete,...during that part of the delivery swing which directly precedes the ball leaving the hand" (Goonetilleke, 1999). A bowling action is now deemed legal if the bowler's elbow angle does not change more than 15° in the period between when the bowling arm is horizontal, and the instance of ball release (ICC, 2005 a). This period is known as the 'delivery phase'. For fast bowlers, the maximum legal change in elbow angle during this delivery phase was set at 10°, 7.5° for medium-pace bowlers, and only 5° for spin bowlers (Lloyd et al., 2000, Elliott et al., 2004, a, Ferdinands and Kersting, 2004). The two key methods employed by biomechanists to evaluate the elbow angle of cricket bowlers include 3-D video analysis (Lloyd et al., 2000, Elliott et al., 2004) and the use of an electrogoniometer (Goonitilleke, 1999). Therefore the objective of this study was to compare the two methods of obtaining elbow angle during cricket bowling, with a view to determining potential differences or similarities in elbow angle determined from testing the same subject with both systems.

METHOD:

Data Collection: Eight male subjects participated in this study (n = 8). This number of subjects is comparable to other cricketing biomechanics studies, which include numerous case studies (Lloyd et al., 2000, Elliott et al., 2001, Elliott et al., 2004 a, b, Goonetilleke, 1999) and studies with subjects numbering 10 or less (Glazier et al., 2000, Elliott et al., 2002). An 8-camera Vicon MX digital motion capture system was used to obtain segment coordinate data during bowling. Motion data was collected at a frequency of 500Hz. The kinematic marker set was the same as that used to obtain the kinematic data for Ferdinands & Kersting (2004) in their investigation of elbow angle during cricket bowling. This marker set consisted of nine reflective 'static' markers which were used to calculate the position of joint centres. Following this static trial, three markers were removed leaving six markers on the body during bowling trials (Ferdinands & Kersting, 2004). An electrogoniometer by

Biovision was used to collect elbow angle data during bowling (Biovision, Germany). The electrogoniometer was placed on the medial aspect of the elbow joint, with the potentiometer component directly over the medial epicondyle and the two 'arms' running along the longitudinal axes of the upper arm and forearm respectively. Data was sampled at a frequency of 500Hz, as used by Goonetilleke in his case-study of Muttiah Muralitharan (Goonetilleke, 1999). The Vicon and data logger data collection systems were synchronised using a system built by Biovision (Biovision, Germany). This synchronisation of systems made it possible to directly compare the output of the two devices over any given bowling trial.

Data Analysis: Following data collection, motion data was digitised within the Workstation software package (ViconPeak, U.K.). In order to filter the coordinate data obtained by the Vicon MX camera system and angular data obtained by the electrogoniometer, a 4th Order zero phase lag Butterworth Filter was conducted within Matlab 6.1 (MathWorks Inc, U.S.A.). This filter type is the same as that used on motion data obtained by Ferdinands and Kersting in their study on illegal bowling actions in cricket, as well as by Ferdinands in his PhD analysis of bowling actions (Ferdinands & Kersting, 2004, Ferdinands, 2003). The electrogoniometer was filtered using the same filter as that used for the motion data so that direct comparisons could be made between the angular data obtained using these two methods. A smoothing frequency of 14Hz was chosen according to the recommendations made by the ICC with respect to the filtering of elbow kinematic data (ICC, 2005, b).
Elbow angle was calculated from the motion data by taking the dot product of two unit vectors created along the longitudinal axes of the upper arm and forearm. The creation of the two unit vectors and the calculation of their dot product was conducted within Matlab 6.1 (MathWorks Inc., U.S.A.). SPSS 12.0.1 for Windows (Apache Software, U.S.A.) was used for statistical analysis of the difference between methods of determining elbow angle. A Univariate ANOVA analysis of variance was conducted using Bonferroni's adjustment to identify differences between the systems.

RESULTS: Frequencies of each response are shown in Table 1. Separate the header of the table by a top and bottom line. Draw a solid line also on the bottom of last item in the list.

Table 1: Average change in elbow angle during the delivery phase

	Marker Data		**Electrogoniometer**	
	Change in Angle (SD)		Change in Angle (SD)	
Sub1	8	2.7	2.1	1.1
Sub2	17.6	1.1	13.8	2.1
Sub3	11.4	4.2	7.2	2
Sub4	9.8	3.2	5.4	1
Sub5	21.3	7.7	14.7	1.9
Sub6	11.7	1	5.1	1
Sub7	13	3.1	11.1	1.9
Sub8	20.9	5.8	1.8	0.7
Mean (SD)	**14.2 (5.08)**		**7.66 (5.01)**	

The Univariate ANOVA analysis of variance showed that statistically significant difference existed between the two systems ($p=0.022$). This difference in calculated change in elbow angle during the delivery phase is shown graphically in Figure 1, a representative graph from subject six.

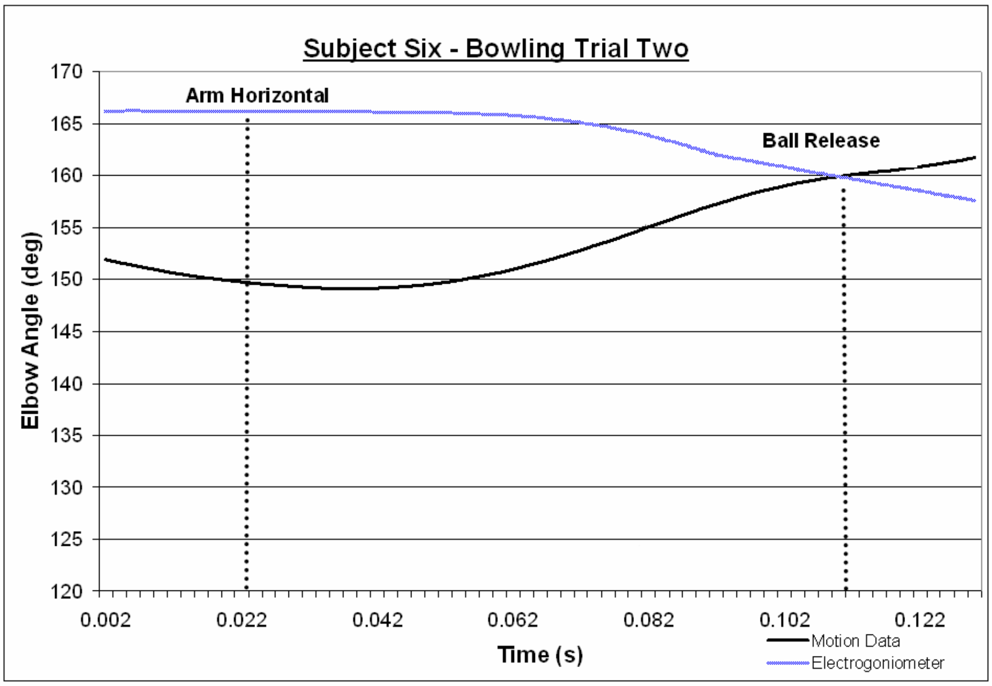

Figure 1: Representative graph of all variables measured in study, synchronised and presented for the second bowling trial from subject six.

DISCUSSION: The objective of this study was to determine if a difference exists in the calculation of elbow angle by two measurement systems. In regard to this objective, a statistically significant difference was found between the two measurement systems.

The results from this study prove that the type of measurement system chosen by the investigator to determine elbow angle, whether it is a marker-based system or an electrogoniometer, can have a profound impact on the results obtained. With respect to the magnitude of change in elbow angle, the marker-based system consistently calculated a greater change in elbow angle than that recorded by the electrogoniometer, with a mean of 14.2° (marker-based) compared to 7.7° (electrogoniometer). Therefore the average change in elbow angle throughout the delivery phase calculated by the marker-based system was twice that calculated by the electrogoniometer.

Possible reasons for such an anomaly between the patterns of movement observed in the two systems include the unknown impact of skin movement due to forearm pronation conducted by bowlers through ball release, as reported by Ferdinands & Kersting (Ferdinands & Kersting, 2004). Another reason for differing results between systems is the possibility of some or all of the subjects possibly having elbow abnormalities. An exaggerated forearm abduction, known as the carry angle was subjectively observed in three of the eight subjects (subject six included). It is possible that due to the type of electrogoniometer used, which consisted of two semi-rigid arms only able to move in a single plane, the arms of the electrogoniometer were not properly placed on the subjects with an exaggerated carry angle since the arms were never entirely flat. Instead, they were stretched across the elbow joint the elbow joint when they were strapped into place. However this would not explain why the same pattern of elbow angle according to the electrogoniometer was seen for most subjects, and not just those with an exaggerated carry angle.

The question remains: what implications do the findings of the current study have with respect to the laws regarding legal bowling actions? With respect to the law governing the maximum allowable change in elbow angle during the delivery phase, some interesting examples exist within the subjects themselves. If the marker-based approach was used for subject two, that bowler would be stated to be outside the current legal elbow angle tolerance level (17.6°). However, if the electrogoniometer method was employed, subject two would be entirely within the legal limits (13.8°).

CONCLUSION: The key finding of this study was that a statistically significant difference was found between the change in elbow angle during the delivery phase calculated by both measurement systems. Possible reasons for this include cross-talk between axes in the electrogoniometer. The electrogoniometer was found to consistently calculate a lower amount of change in elbow angle than the marker-based system. Practical implications for this finding include the fact that a bowler may be found guilty of an illegal bowling action using one system, but indemnified as innocent by the other. Without an absolute ‘gold-standard’ measurement system, however, it is difficult to discern which system is more valid.

REFERENCES:

Bartlett, R. M., Stockill, N.P., Elliott, B.C., Burnett, A.F. (1996). The biomechanics of fast bowling in men's cricket: a review. Journal of Sports Sciences, 14, 403-424.

Elliott, B., Alderson, J., Reid, S., Foster, D. (2004 (a)). Bowling report: Mr. Muttiah Muralitharan. Perth: University of Western Australia.

Elliott, B., Chin, A., Foster, D. (2004 (b)). Bowling Report – Mr Shoaib Malik. Perth: University of Western Australia.

Elliott, B., Foster,D. (1989). Fast bowling technique. In B. Elliott, Foster, D.,

Elliott, B., Lloyd, D., Alderson, J., Foster, D. (2001). Final Bowling Report - Mr Shoaib Akhtar. Perth: University of Western Australia.

Elliott, B., Plunkett, D., Alderson, J. (2005). The effect of altered pitch length on performance and technique in junior fast bowlers. Journal of Sports Sciences, 23(7), 661-667.

Elliott, B., Wallis, R. Sakurai, S., Lloyd, D., Besier, T. (2002). The measurement of shoulder alignment in cricket fast bowling. Journal of Sports Sciences, 20, 507-510.

Ferdinands, R. (2003). Three-dimensional biomechanical analysis of fast bowling in cricket. Unpublished PhD, The University of Waikato.

Ferdinands, R., Kersting, U.G. (2004). The biomechanics of illegal bowling actions in cricket. *http://coachesinfo.com/category/cricket/351.*

Glazier, P., Paradisis, G., Cooper, S.M. (2000). Anthropometric and kinematic influences on release speed in men's fast-medium bowling. Journal of Sports Sciences, 18, 1013-1021.

Goonetelleke, R. S. (1999). Legality of bowling actions in cricket. Ergonomics, 42(10), 1386-1397.

ICC. (2005). Code of Conduct, from www.ICC-cricket.com

ICC. (2005). Regulations for the review of bowlers reported with suspected illegal bowling actions, from www.ICC-cricket.com

Lloyd, D. G., Alderson, J., Elliott, B.C. (2000). An upper limb kinematic model for the examination of cricket bowling: a case study of Mutiah Muralitharan. Journal of Sports Sciences, 18, 975-982.

Acknowledgements

Paul Marshall, Paul McAlpine, the Department of Sport and Exercise Science at The University of Auckland, and all subjects who participated in this study.