ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

THE EFFECT OF MARKER PLACEMENT AT THE ELBOW ON CALCULATED ELBOW EXTENSION DURING BOWLING IN CRICKET

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SUMMARY
In this study the effect of two different marker placements at the elbow for determining bowling arm kinematics was investigated. Three pairs and one triad of reflective markers, defining two marker sets, were placed on the bowling arm of twelve elite fast bowlers. The first marker set used three pairs of markers while for the second marker set the pair of markers at the elbow were replaced by a triad of markers on the upper arm. Using three pairs of markers gave realistic levels of elbow extension wheras using a triad of markers to calculate elbow motion resulted in calculated angles that did not correspond well with video recordings for some bowlers.

INTRODUCTION
The topic of whether a bowler is bowling legally or not is a contentious issue that causes much debate and confusion. The current procedure is that if an umpire is of the opinion that a player is bowling with an action which contravenes Law 24 of the International Cricket Council (ICC) rules then an independent analysis of their bowling action will be carried out by an approved human movement specialist under laboratory conditions [1]. Currently there are two alternative marker sets being used to quantify elbow extension angles during bowling [2, 3]. The aim of this study was to compare the effect of two different marker placements at the elbow for determining bowling arm kinematics in the laboratory.

METHODS
Three pairs and one triad of reflective markers, defining two marker sets, were placed on the bowling arm of twelve elite fast bowlers (Figure 1). In addition a piece of reflective tape (≈1.5 cm square) was attached to one side of the cricket ball. The first marker set consisted of a pair of markers at the wrist, elbow and shoulder with each joint centre defined as the mid-point of each pair of markers. At the wrist the pair of markers were positioned near the styloid processes such that the midpoint of the pair of markers lay on the midline of the lower arm. At the elbow the pair of markers were positioned vertically above the medial and lateral elbow epicondyle bony landmarks (when the arm was horizontal and the palm of the hand was facing upwards) so that the midpoint of the pair of markers lay on the midlines of the upper arm and lower arm. At the shoulder the pair of markers were positioned (anterior and posterior to the shoulder) with the arm overhead so that the line joining these markers intersected the midline of the upper arm [2].

The second marker set used the same marker placement at the wrist and shoulder and with a triad of markers placed on the upper arm just above the elbow joint (Figure 1).

Figure 1: Nine 14 mm reflective marker placement.

For each bowler three trials were recorded using a Vicon motion analysis system recording at 300 Hz: a static straight arm trial overhead, an elbow flexion trial [2] and a bowling trial. The static overhead trial was used to define the pair of elbow markers relative to the triad of markers, the elbow flexion trial was used to define a functional elbow axis [2] for both markers sets, and for each bowling trial the elbow flexion / extension angle time history was calculated using each marker set. For each bowling trial the elbow extension angle was noted for the following times / positions; upper arm horizontal, minimum extension angle, subsequent maximum extension angle, and ball release.

RESULTS AND DISCUSSION

Substantial differences in calculated elbow extension angles were found between the two marker sets (Table 1) for some bowlers (e.g. Figure 2; bowler 12) whereas for other bowlers the differences were much smaller (e.g. Figure 2; bowler 5). For all bowlers the elbow flexion / extension angles calculated using the three pairs of markers were smoother than the angles calculated using the second marker set.

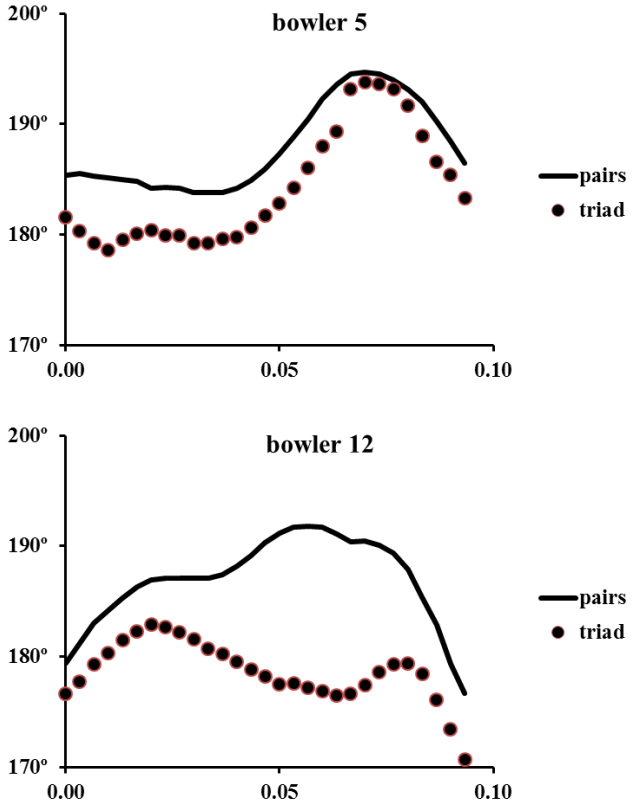

Figure 2: Example trials where the two marker sets resulted in similar calculated elbow angles (bowler 5) and substantial differences (bowler 12) between upper arm horizontal and ball release.

Typically the three pairs of markers resulted in elbow angle time histories that went from a relatively straight position at upper arm horizontal into hyperextension and then back to a relatively straight position by ball release (Figure 2). This was consistent with visual observations of high speed video recordings of each bowler. In contrast the second marker set where the pair of markers at the elbow were replaced by a triad of markers resulted in time histories with more oscillations and fluctuations in elbow angle (Figure 2). These oscillations were attributed to movement of the triad markers relative to the elbow axis due to placement of the triad over soft tissue of the upper arm. The pair of markers around the elbow are likely to have less movement artefacts arising from skin movement during internal / external rotation of the upper arm than small triads placed over soft tissue.

CONCLUSIONS

Using three pairs of markers to determine the amount of elbow extension between upper arm horizontal and ball release for cricket bowling gives realistic levels of elbow extension when compared to video recordings of each bowling trial. In contrast, using the triad of markers to calculate elbow motion resulted in calculated angles that did not correspond well with video recordings for some bowlers.

ACKNOWLEDGEMENTS

The England and Wales Cricket Board for providing the indoor facility for data collection.

REFERENCES

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Table 1: Elbow flexion / extension angles [°] at key instants in the bowling action and calculated elbow extension [°] for each bowler using the two marker sets.

	upper arm horizontal		**minimum angle**		**subsequent maximum angle**		**ball release**		**elbow extension**	
bowler	pairs	triad	pairs	triad	pairs	triad	pairs	triad	pairs	triad
1	183	186	180	183	191	189	175	174	0	0
2	188	175	188	162	194	166	180	166	0	4
3	182	188	180	187	191	196	174	178	0	0
4	172	174	163	155	173	170	172	170	10	15
5	185	182	184	179	195	194	185	180	0	1
6	182	190	181	176	188	183	181	172	0	4
7	178	172	178	172	184	176	175	167	2	4
8	179	175	177	171	188	180	185	179	3	9
9	177	174	177	174	183	182	173	173	3	6
10	184	184	184	184	193	189	178	172	0	0
11	178	176	178	176	199	193	180	178	2	4
12	179	177	179	177	192	179	177	171	1	2