

# THE EFFECT OF DIGITISATION OF THE ELBOW EPICONDYLES ON QUANTIFYING ELBOW KINEMATICS DURING CRICKET BOWLING

<sup>1,2</sup>Theofano Eftaxiopolou, <sup>2</sup>John P Dear, <sup>1</sup>Anthony MJ Bull

Departments of <sup>1</sup>Bioengineering and <sup>2</sup>Mechanical Engineering, Imperial College London, London SW7 2AZ, U.K;  
email: theofano.eftaxiopolou06@ic.ac.uk, web: www3.imperial.ac.uk/bioengineering

## INTRODUCTION

In the sport of cricket the objective of the 'no-ball' law is to restrain the bowler's arm in a fixed position so that there is no straightening or bending of the elbow joint during ball delivery. Since the advent of high-speed video photography it has been revealed that some straightening occurs in bowlers who have actions that are traditionally considered in accordance with the law. This is due in part to the carrying angle of the elbow (varus/valgus angulation) [1]. For this reason the International Cricket Council (ICC) in the 1990s decided to allow a small amount of elbow extension to occur, which in 2004 was extended to 15° for elbow extension for all types of bowlers.

The methods that are currently used to measure the 3D motion of the bowling arm and conclude whether a bowling action is legitimate or not are optical motion tracking systems, where markers are attached to the bowling arm of bowlers whose bowling action is subsequently recorded. In previous studies, when markers were placed directly on the elbow epicondyles, there were significant errors reported during elbow flexion/extension due to excessive skin movement; this was particularly evident in full elbow extension [2]. In order to account for this error the positions of the two elbow epicondyles are digitised relative to other markers that are fixed elsewhere on the two body segments – the upper arm and the forearm. The aim of this study is to compare three different methods for digitising the humeral epicondyles and investigate their effect on the measurement of the elbow flexion angle during cricket bowling.

## METHODS

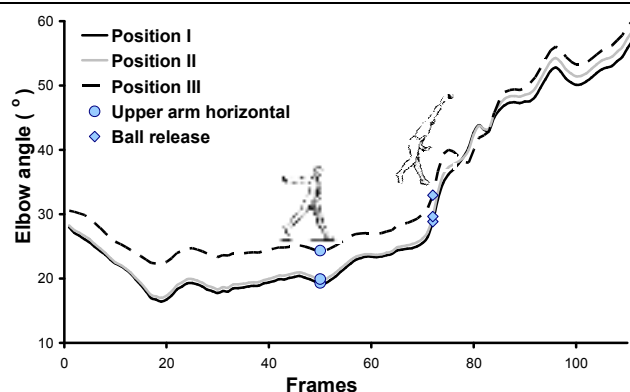
An optical motion tracking system (MX-13+, Vicon, Oxford, UK) was used at an acquisition rate of 200 Hz to track reflective markers attached to the skin of the bowlers. A video recorder was also used to record the delivery swing. The position of each elbow epicondyle was defined relative to the position of the local coordinate system of the calibration wand in static trials before data collection [3]. The tip of the wand was placed onto the anatomical landmark of each epicondyle and local coordinate frames were then introduced on the segments of the upper arm and the wand from which the position of each epicondyle in 3D space was calculated by simple geometric calculations [4]. During data capture of the bowling action the position of each epicondyle was reconstructed with respect to the segment of the upper arm [3 - 5].

Three different positions were investigated: when the elbow was flexed (Position I), when the elbow was in full extension (Position II) and when the elbow was flexed with the humerus internally rotated (Position III). Seven bowlers from the Imperial College cricket team participated in this study. After digitisation of the elbow epicondyles each

bowler completed a total of ten deliveries, from which six successful deliveries were collected for analysis; this consisted of calculating the flexion/extension of the elbow at the point that the upper arm reached the level of shoulder until ball release. This definition is in accordance with the relevant law in cricket that is associated with 'no-ball'.

## RESULTS

Average elbow joint flexion changes during the bowl were 10.9° (SD: 1.5°; Range: 9.1° – 11.8°). The calculated elbow flexion angles were 11.8° (± 3.8°) and 11.7 (± 3.4°) for positions I and II, respectively; these were statistically significantly greater ( $p < 0.0002$ ) than those calculated for position III, in which the changes were 9.1° (± 3.9°).



**Figure 1:** Elbow flexion/extension angle, for one bowler for all three elbow positions (I, II and III) (Bowler images taken from [6]).

## DISCUSSION AND CONCLUSION

In this study the range of the recorded motion showed that the position of the elbow joint during the digitisation process has a significant effect in the determination of the elbow angles. These results indicate that using a newly defined position to digitise the humeral epicondyles in optical motion tracking analysis of cricket bowling gives more consistent and lower measures of elbow joint flexion/extension during the ball delivery.

## ACKNOWLEDGEMENTS

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