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## Case studies of the centre of pressure between hand and ball in off-spin bowling, analysed with a smart cricket ball

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### Abstract

In off-spin bowling (finger-spin delivery with a sidespin, right-handed bowler), the ball rolls over the middle finger and rotates counterclockwise, as seen by the batsman. It is therefore expected that the torque imparted onto the ball is generated by the middle finger and the centre of pressure (COP) is also located close to the middle finger. The off-spin bowling action was recorded in five bowlers with a smart cricket ball and the COP was determined. In two bowlers, the COP was located at the middle finger and moved clockwise, i.e. against the sense of the ball, inherent to rolling motion. In one bowler, the COP was shifted slightly to the index finger, indicating a small contribution by the index to torque generation. Another bowler initiated the torque generation with the index finger, and then the COP moved from index to middle finger. The fifth bowler produced a rare case of braking i.e. deceleration of the ball at release, with the tip of the index finger, as seen in the location of the COP. In this case, the COP moved from the middle finger to the index. This preliminary study of off-spin bowling contributes to the understanding of torque generation, confirming that the primary torque generation is by the middle finger, a mechanism that could be more effective when combined with the torque generation by the index finger.

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### 1. Introduction

In spin bowling, the fingers are arranged along, and spread across, the seam of the ball in order to achieve maximal spin of the ball. The rotation of the ball is generated in the forearm joints (pronation / supination), in the wrist joint (ab/adduction, extension / flexion) and in the finger joints (ab/adduction, extension / flexion, opposition / reposition). The torque produced by the forearm muscles and small hand muscles imparts spin on the ball through frictional contact between the fingers and the ball, a process that is assisted by the rough prominence of the seam. Regarding the torque transfer from the fingers to the ball, the main research questions are: (1) which fingers are mainly involved in transferring the torque, and (2) whether one finger produces the torque exclusively or whether the fingers are engaged consecutively, one after the other, in transferring the torque.

Fuss et al. [1] conducted a study on performance parameters, such as the spin axis vector diagram and the centre of pressure (COP), with a smart cricket ball in one off-spinner. They concluded that the centre of pressure is located on the palmar side of the ball, between middle and ring fingers and that the peak torque is jointly imparted by these two fingers. However, if index and middle finger were spread slightly more than shown in figure 5 of [1], then this torque would have been exclusively generated by the middle finger.

The aim of the research was to discover where the centre of pressure was located with respect to the spinning fingers, i.e. which fingers produced the maximum torque at which stage of the torque phase, and how the centre of pressure moved with respect to the motion of the ball, by using Mark 2 of the RMIT Smart Cricket Ball [2,3].

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## 2. Method

The smart ball electronics consists of a circular PCB (printed circuit board) of 34 mm diameter; a small LiPo battery (lithium polymer); three high-speed gyroscope sensors; a flash memory; a Bluetooth module; a coil for wireless inductive charging; and a microcontroller [2]. The microcontroller has a built-in 10 bit ADC (analog to digital converter) which converts sensor's analog output signal to digital format [2]. As the maximum speed recorded by one gyro is 55.56 rps, the resolution of the smart ball is 0.054 rps. The static noise of the gyros has a standard deviation of 0.136 rps. The raw rps data are filtered with a low pass 3<sup>rd</sup> order Butterworth filter at a cut-off frequency of 30 Hz.

The bowling actions of five off-spinners (from different levels of competition, ranging from amateur level to 1<sup>st</sup> class cricket) were tested and analysed with the smart cricket ball. Each bowler delivered 3-10 off-spinners, a finger-spin delivery bowled having a component of side-spin. The COP was calculated with the method of [1], and displayed on the ball. After the trials, photos were taken of two bowlers (bowlers 1 and 4) when holding the ball in their hands. The ball was visualised as being cut in half (Fig. 1), with the palmar hemisphere remaining in the bowler's hand. The reason for this was that the COP was located on the palmar hemisphere, and therefore cannot be projected onto the other hemisphere. The COP was visualised in AutoCAD2000 (Autodesk, San Rafael, CA, USA) in 4D, with bubbles indicating the location on the surface of the ball, the bubble diameter denoting the magnitude of the torque, and their colour referring to the time (as 4<sup>th</sup> dimension). The COP was coded with rainbow colours, where the time series started with red and ended with purple. This is important insofar as the COP moved across the surface of the ball, and the direction of movement indicated rolling motion and/or torque shift. The COPs of bowlers 2, 3 and 5 were projected on the grip of bowler 1 due to similar grip patterns. A photo of the grip of bowler 4 was taken in the early stage of torque generation. Ethics approval for this study was granted by the RMIT University Human Ethics Committee.

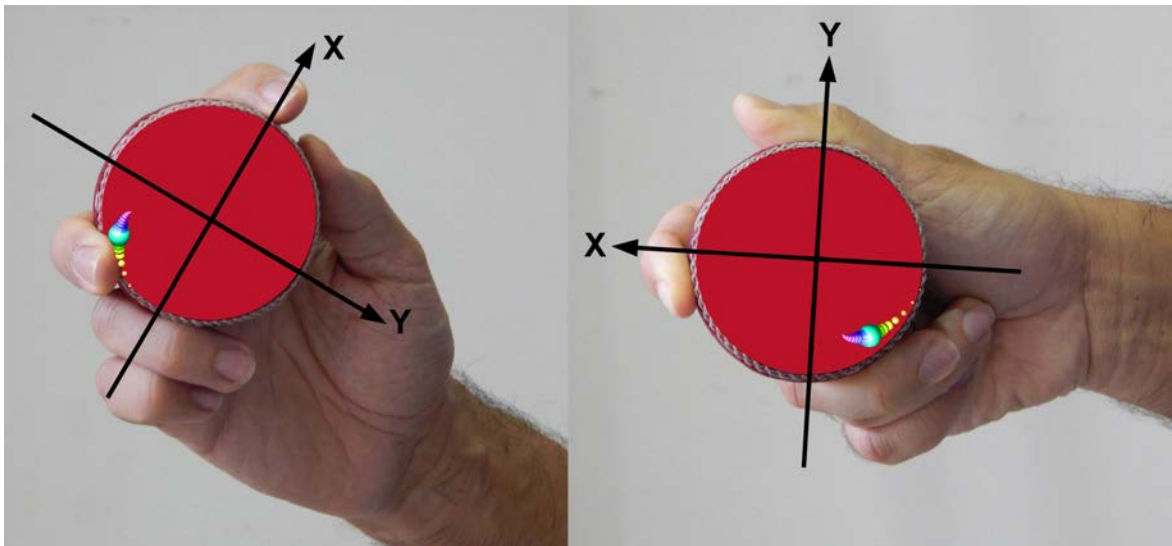


Fig. 1. Bowler 1, grip and COP in the early (*left*) and final (*right*) stage of torque generation; X, Y: axes of the ball's coordinate system; the centre of pressure is colour coded, with rainbow colours, where the time series starts with red/orange and ends with purple/magenta; the bubble diameter of the COPs is proportional to the magnitude of the torque; the ball is visualised as being cut in half with the palmar hemisphere remaining in the bowler's hand; the COP is located on the palmar hemisphere

## 3. Results

### 3.1. Bowler 1

Fig. 1 shows that the COP was located at the middle finger, slightly off the seam, on the palmar hemisphere of the ball. The ball rotated counterclockwise in Fig. 1, but the COP moved in clockwise direction. This indicated rolling motion of the ball over the middle finger, and the torque was exclusively generated by the middle finger.

### 3.2. Bowler 2

In bowler 2, the COP (Fig. 2) there were some minute differences in the path curve of the COP compared to bowler 1; however, the movement pattern of the COP was the same as in bowler 1.

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