

Physics in Sports – Cricket bowling action

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Work and energy play a significant role in sports. Every sport's discipline depend on the ability of an athlete to exercise a force. In Physics, if a force moves an object to a certain distance, it is defined as a work. Force and work are directly proportional to each other. Understanding the physics behind the sports will improve the overall performance. It includes better performance by improving the game related techniques, injury prevention, planning of efficient training and developing aerodynamic equipment and clothing.

Physics can be used to monitor the precision timing of athletics

movements, as timing is one of the key things that take them to the winners' podium. Wearable sensors will measure forces applied during the play. This information can be used to improve their timing as well as precise postures during the game. Their coach can review a graph of force at different times during the training sessions and improve the game based techniques. In running, cycling and summing, a resistance force is experienced due to air or water in which they are moving. A cyclist can minimize this resistance force by changing the position, which results to reduce the cross sectional area. They can further reduce the drag force by hugging their bodies tightly to the bike's frame. Rather than pushing against the resistance

force, a right design of materials may lead to more fluid flow around his/her body. In swimming, wearing a full body swimming suits will squeeze swimmers into smaller cross-sectional area, which results in eliminating skin friction and allowing water to flow over the body more easily.

Understanding the aerodynamics of the ball is important in defining its trajectory in all high speed ball sports such as cricket, baseball, golf, tennis, volleyball and football. The aerodynamics behaviour results to deviate the anticipated trajectory of the ball resulting in a curved and unpredictable trajectory. In most of these high speed ball sports, the lateral deflection is produced by spinning the ball about an axis perpendicular to the line of flight/delivery. This lateral deflection is

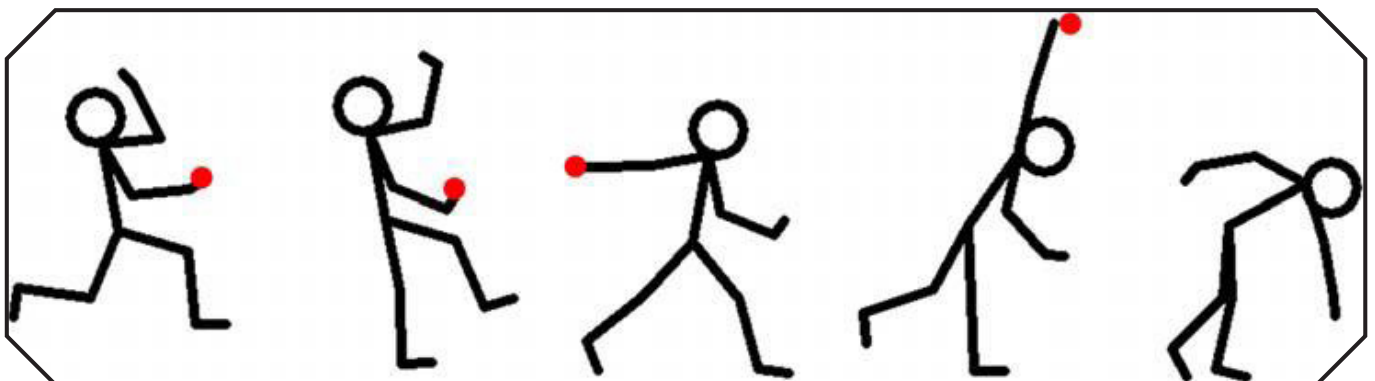


Fig 1: Strike of bowling action sequence: delivery jump, back foot contact, front foot contact, ball release and follow-through

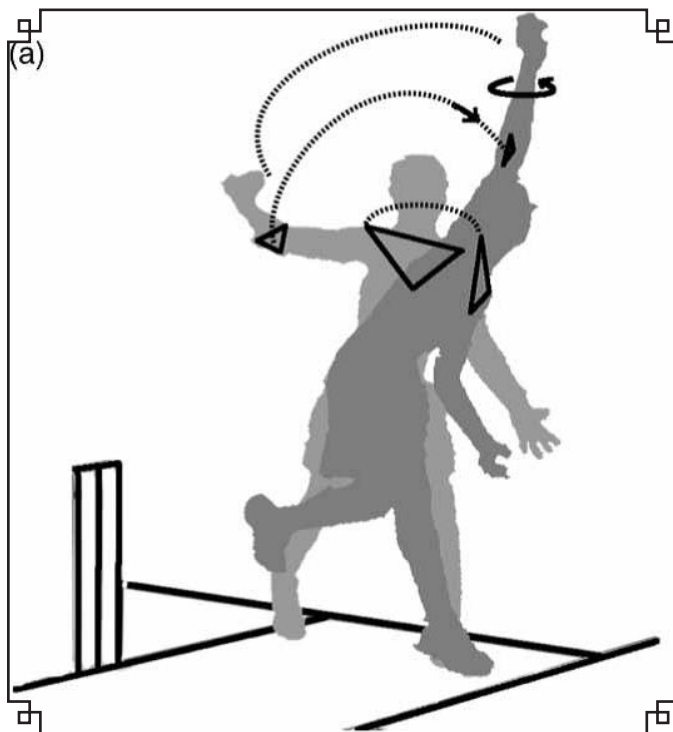


Fig 2: Spin bowler going from the start of the bowling action to just before ball release

commonly known as swing, swerve or curve.

Cricket is one of the most favourite games in the Indian sub-continent. It is a bat and ball game. It has three major parts; batting, bowling and fielding. The batsman is supposed to hit the ball hard and score the runs. Theoretically, heavier the bat and faster the bat (stroke) acceleration, greater the force applied on to the ball. When an accurately timed and accelerated bat hits a ball, which would cause an increase in the momentum, this consequent result would be a great shot, a four or a six. In the case of a defensive shot, a ball hits a stationary bat, which results in a loss of momentum.

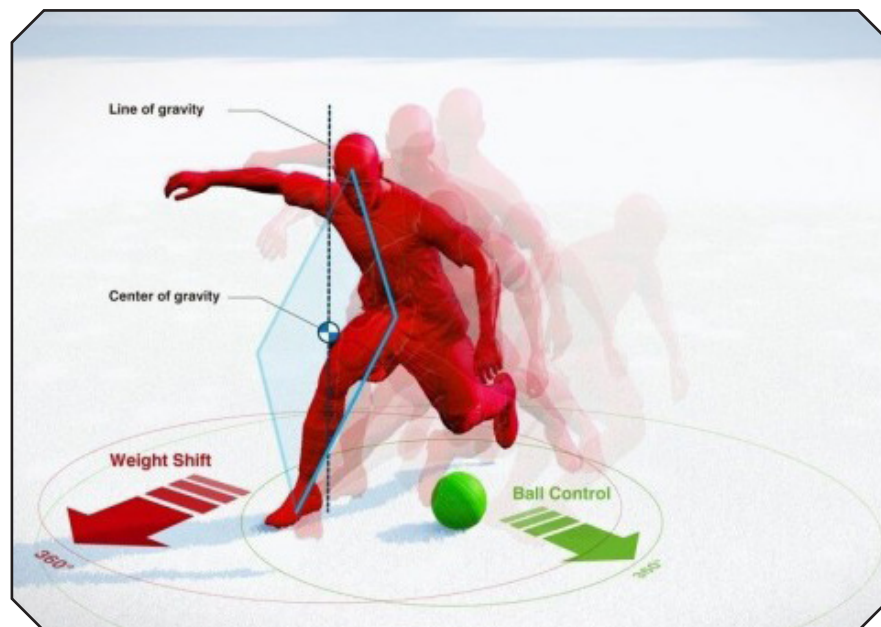
The basic cricket bowling action has a run-up phase. It is similar to javelin throwing. The bowler's run-up begins slowly. He then gradually

increases the speed until the pre-delivery phase when he leaps into the air in preparation for the phases to follow: back foot contact, front foot contact, ball release and follow-through as shown in Figure 1. The aim of this article is to discuss the bowling action in detail.

According to the International Cricket Council (ICC) regulations, a fair delivery of the ball is achieved when elbow joint is not partially or completely straightened from the point the arm has reached the level of shoulder until the ball has been released. Identifying the illegal bowling action of the player in the

juvenile stage is very important. It helps to biomechanically correct his/her bowling action according to the ICC standards. In addition, biomechanical examinations of those players at the early stage helps them to eliminate game based injuries by improving muscle strengthening.

Chucking in bowling is becoming one of the key issues in the cricket world. The infamous no-balling incident of Muttiah Muralitharan during a game in 1995 against Australia, where he was no-balled seven times in the same match for chucking, led the ICC to alter the rules regarding this controversial issue. Since then, ICC has introduced the Law 24.2 to identify illegal bowling action. This law states that, if an umpire suspects the bowling action of a player, then the player is directed to carry out an independent analysis of his/her bowling action by an approved human motion specialist under laboratory conditions. According to ICC report for 2009, the legally permitted elbow extension angle is 15° during the period between



upper arm being horizontal and the ball releasing instant. This angle does not include any elbow abduction angle changes or hyperextension.

In Biomechanics of the bowling action, the elbow joint is a hinge joint. It moves through flexion and extension. The elbow flexion is the forward and upward movement of the forearm, while extension is the backward and downward movement of the forearm.

Theoretically, the bowler should maintain the same elbow extension angle until the latter parts of the delivery (Figurer 2). As the bowling arm circumducts to the position of ball release, a 15° tolerance threshold is applied to the limit of elbow extension between the arm at horizontal and the position of ball release. This horizontal position is considered when the arm is parallel to the ground, while the ball releasing position is considered as the last moment of the ball release from bowler's fingers. This tolerance threshold was introduced by ICC in 2005, after a biomechanical assessment of the bowling action of 130 first-class bowlers. A well-recognized method is needed to accurately measure the elbow extension angle during a delivery

and to identify when the arm is horizontal. Such a method will help identify the possible hyperextension of the elbow. A video analysis

bowling action. However, it is not possible to use this method because the elbow axis changes throughout the bowling action. Therefore,

laboratory marker method is commonly practised.

The definition of the elbow flexion or extension axis may affect the quantity of elbow extension angle for a specific bowling trial. The current ICC testing protocol (2009) refers to the methods described in Lloyd *et al* (2000) for flexion/extension axis, which is defined to be perpendicular to the longitudinal axis of upper arm in frontal plane.

The elbow flexion/extension angle is derived at shoulder-elbow-wrist angle. 0° being full extension and 180° being full flexion. Furthermore, this elbow flexion/

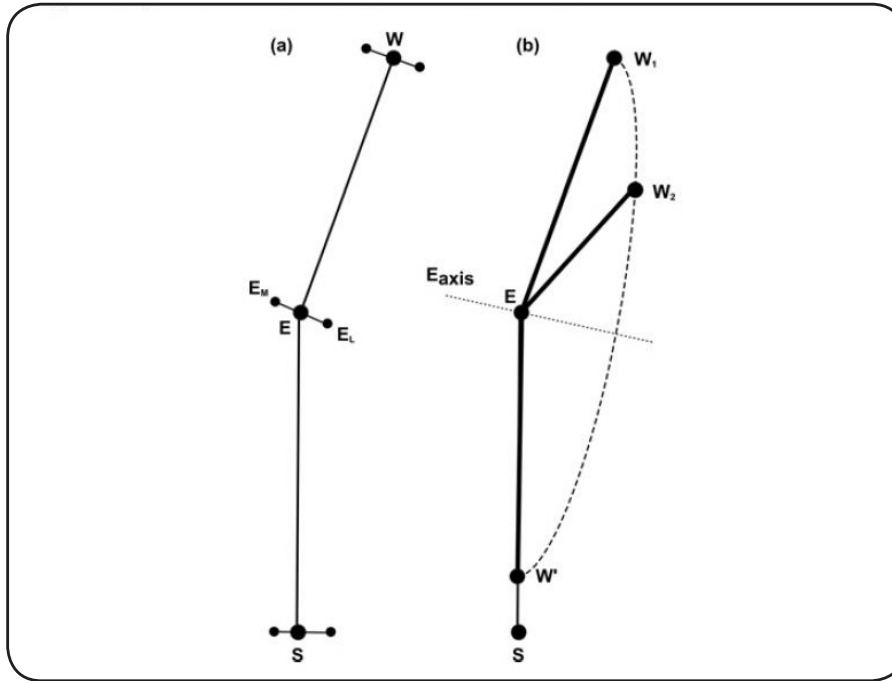


Fig 3 : a) Shoulder, elbow and wrist markers b) elbow axis calculation. W-Wrist, E- Elbow, S- Shoulder, W1 and W2 are recorded positions of wrist from elbow flexion calibration trial for extension angles of approximately 180° and 90°. W' is an assumed point on the upper arm.

is a possible method that can be practised to measure the elbow extension angle in the event of the elbow axis being parallel to the video camera axis during the

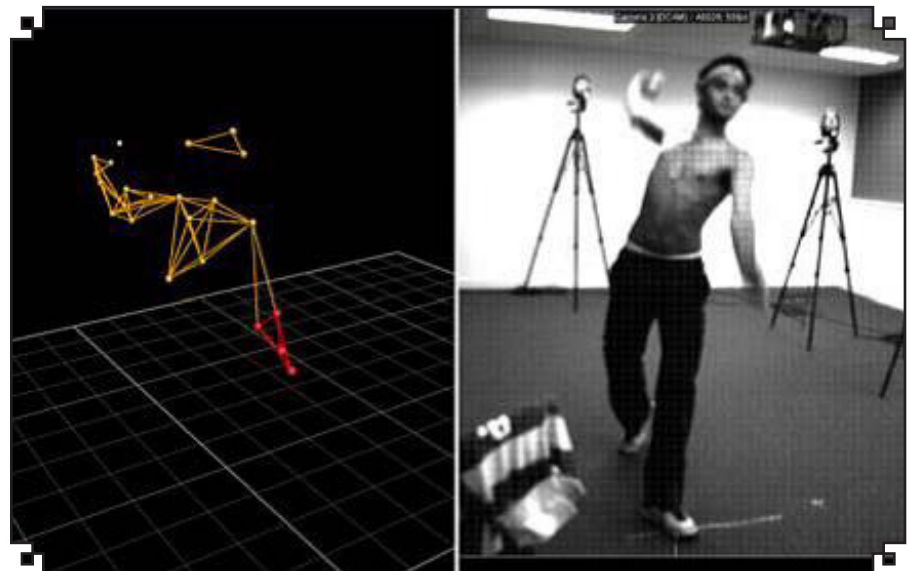




Fig 5 : ii) Determining the lateral elbow epicondyle position

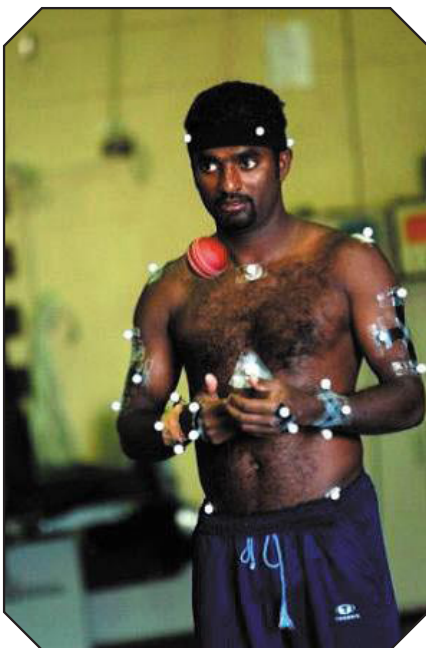


Fig 5 : i) Upper body model

extension angle is defined about the flexion-extension axis of the elbow. Elbow flexion-extension occurs along this axis. This elbow extension determines whether a bowler is 'throwing'. Figure 3 shows the calculation of elbow axis.

The kinematics models of upper

limb during cricket bowling action is created to describe the movements of upper arm and forearm during each delivery. With that, the flexion-extension angle of elbow is analysed during the bowling action. In addition, the range of motion and physical characteristics of bowling action can be measured (Figure 4).

Furthermore, motion data capturing of traditional biomechanical models were performed by positioning the markers over the selected anatomical landmarks to define the joint centers as shown in Figure 5. As a result of excessive skin movement, significant errors were introduced in joint center and the axes of rotation. This effect is significantly evident in full elbow extension, while external markers placed on elbow epicondyles results in elbow flexion artefact. As a

result, errors can be attributed to transepicondylar axis of the elbow joint (flexion/extension axis). This artefact effect is further worsen with individuals having joint abnormalities. Therefore, these traditional models failed when applied to analyse the biomechanics of bowling action of players with joint abnormalities, Such as Muthiah Muralitharan, Shoaib Akhtar and Jenny Gunn. In such abnormal anatomical

orientations of the arm (Ex; hyperextension or higher carrying angles), these traditional models should be implemented with caution to address such abnormalities. Different research groups have been developing and validating biomechanical models for motion analysis over the last decades. Furthermore, these biomechanical models are capable of measuring the elbow joint angle by eliminating soft skin effect and blower based anatomical abnormalities.

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