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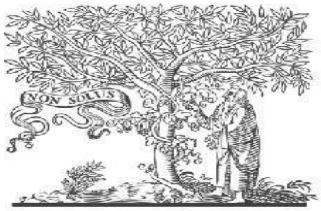

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IDENTIFYING THE BOWLING TECHNIQUES USED BY FEMALE BOWLERS

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ABSTRACT
Cricket is not just about hitting runs but for a good team performance bowling is also very important. The art of pace bowling in cricket is one of the toughest and also important skills to execute. Fast bowling is a critical aspect of cricket, requiring precise biomechanical movements for optimal performance. Five fast bowlers from the Indian women's cricket squad were filmed using two synchronized cameras operating at 125 Hz. AP AS™ motion analysis software (Ariel Dynamics Inc., USA) was used to manually digitize joint centers. Shoulder and hip segment orientations were calculated 'by' projecting a line joining the shoulder joint centers and a line joining the hip joint centers onto the transverse plane. Therefore, this study aims to bridge this gap by examining the kinematic characteristics, including joint angles, segmental movements, and timing, associated with fast bowling in female cricketers.

Keywords: Cricket, Bowling, Shoulder, Hip, Kinematic

I. INTRODUCTION

In cricket, the players on each team take on certain duties, such as batting, bowling, or fielding, that determine how they primarily contribute to the game. To limit the quantity of runs scored by the other team by getting rid of their hitters is the top priority for a bowler. In order to get batters out, pace bowlers try to increase their ball release speed (BRS) as much as possible and reduce the amount of time the batsman has between the delivery of the ball and when they must make the necessary stroke.

Batting, bowling, maintaining wickets, and fielding are all essential to the game of cricket, one of the most played sports in the world. In cricket, speed bowling is a difficult and crucial talent to master. It's not all about scoring runs in cricket; if the team can't defend the score, it doesn't matter how many runs they put up. Bowlers' primary objective is to get rid of the batter in order to keep the score low. One aspect of bowling that comes to mind when discussing accuracy is the bowl's line and length, or, to put it more simply, a bowler's goal should be to consistently pitch the ball in the good length region. If you want to play a good length delivery, you must play it straight and that is to defend. This is because a good length ball is a ball that gives some doubt or indecision about whether to go on the front foot or play on the back foot. As opposed to pace bowlers, they have to consider several factors besides speed before making an attack. Accuracy and control are the primary tools that enable a medium pacer to capture wickets.

While fast bowling has traditionally been associated with male cricketers, the sport has seen a remarkable growth in women's cricket in recent years. With the rise in

popularity and professionalism of women's cricket, an increasing number of talented female cricketers are embracing the art of fast bowling. However, there remains a noticeable dearth of research and understanding specifically focused on the kinematic analysis of fast bowling techniques employed by elite female cricketers.

Kinematic analysis plays a crucial role in examining the movement patterns, joint angles, and timing of various body segments during a specific skill or activity. It provides valuable insights into the biomechanical aspects of an action, helping to optimize performance, prevent injuries, and refine coaching methodologies. In the context of fast bowling, kinematic analysis allows us to gain a comprehensive understanding of the techniques utilized by female cricketers and explore any potential gender-specific differences in their bowling actions.

II. REVIEW OF LITERATURE

Sanders, Liam et al., (2018) The purpose of this research was to determine the most important kinematic variables that are related to increased spin rates in professional finger spin bowling. Twenty-three of the world's best male finger spin bowlers had their kinetic data recorded, and thirty kinematic characteristics were determined for each delivery. Kinematic characteristics related to spin rate were identified using stepwise linear regression and Pearson product moment correlations. The greatest predictors of spin rate were found to be pelvis orientation at front foot contact ($r = 0.674$, $p < 0.001$) and ball release ($r = 0.676$, $p < 0.001$), together explaining 43% of the observed variance in spin rate. Shoulder orientation at ball release ($r = 0.462$, $p = 0.027$) and pelvis-shoulder separation angle at front foot contact ($r = 0.521$, $p = 0.011$) were additional kinematic factors connected with spin rate. In addition to a wider pelvis-shoulder separation angle and a shoulder orientation just short of side-on at front foot contact, the greatest spin rate bowlers also chose a midway pelvis orientation angle. The segments rotated in turn, beginning with the pelvis and ending with the forearm pronating. The information gained here can help instructors better instruct their players in the art of finger spin bowling.

Schaefer, Andrew et al., (2017) International cricket organizations suggest limiting training/match effort for bowlers under the age of 19 due to the high prevalence of lumbar spine injury among fast bowlers. The goal of this research was to identify any statistically significant changes in fast bowling technique or movement variability throughout an extended 10-over bowling session. Twenty-five male junior fast bowlers bowled at competition speeds while kinematic and kinetic data was taken from their leading leg, trunk, and bowling arm in three dimensions. The means and standard deviations of each variable were independently analyzed using repeated measures factorial analyses of variance and effect size calculations. High levels of consistency in kinematic and kinetic patterns were found, with no significant shifts in mean values or variability of any kinematic, kinetic, or performance variables. Because of this, it is not reasonable to restrict bowlers' workload on the grounds that doing so increases their risk of lumbar injury due to changes in

their bowling technique and loading habits. Instead, research on injury prevention should center on the cumulative toll of several spells and the fast bowling method itself.

Samuel Callaghan et al., (2017) With the advent of Twenty20 cricket and other shorter match forms, the ability to hit a rapid single throughout a game has become increasingly important. Therefore, the purpose of this study was to compare and contrast the kinematic factors of batsmen and fast bowlers as they ran a single. Using a match-specific start (walking start, bat pulled through crease, and leg protectors on), eighteen male cricketers ran a distance of 17.68 meters. The times at the 0-5 and 0-17.68 m timing gates were recorded. Motion analysis was used to examine the first and second steps' joint and step kinematics. Players were divided into two categories, fast bowlers and batters, to reflect their respective roles on the field. Differences between the batters and fast bowlers were shown to be statistically significant (p 0.05) using a one-way analysis of variance. We also computed effect sizes using Cohen's d. There were some kinematic differences between the groups. The non-dominant elbow flexion and second-step swing-leg ankle dorsi flexion of fast bowlers were substantially higher than those of slow bowlers. An expanded range of motion in the bowling arm and an enhanced dorsi flexion on front and back foot landing are both characteristics of fast bowling technique, suggesting that the demands of the sport may have had a cross-training impact. However, neither group outperformed the other in terms of rapid single sprint speed. No of their position on the squad, cricket players should be experts in the techniques of swift single sprint acceleration.

Ferdinands, Rene et al., (2014) The researchers wanted to see if there was a correlation between the speed at which the ball is released and the kinematics and kinetics of the fast bowler's back leg drive. The bowling motions of eighteen young fast bowlers (17.2 ± 1.7 years old) were collected by a Cortex 2.0 motion analysis device (200 Hz) and analyzed. To analyze the correlations between bowling wrist speed and the kinematics and kinetics variables associated with rear leg motion, SPSS (Version 17.0) was used to construct bivariate Pearson's product-movement correlation coefficients. Most of these kinematic variables occurred during the delivery stride, but the mean thigh extension angular velocity ($r = 0.606$, $p = 0.008$), thigh adduction angular velocity at back foot contact ($r = 0.515$, $p = 0.029$), and maximum change in knee extension angular velocity ($r = 0.559$, $p = 0.016$) were all correlated with bowling wrist speed. Research also revealed that the use of the hind legs to propel the body forward is not an intentional one. Instead, regulated and minimal torque motion-effects were often applied to hip and knee motions in the flexion-extension and adduction-abduction planes.

Ferdinands, Rene et al., (2013) While segmental sequencing has been the subject of several studies in other sports, cricket bowling has received very less attention. With ball speeds ranging from 27.0 to 35.6 m s-1, this research examined 34 fast bowlers (22.3 ± 3.7 years) from elite grade level and beyond utilizing 3D motion analysis. The findings showed that bowlers

demonstrated a general order of proximal-to-distal sequencing, and a one-way repeated measures ANOVA was used to assess for within-participant variations in segmental sequencing based on the time of maximal segmental angular velocities and kinetic energies. Relationships between kinematic factors and ball release speed were evaluated using bivariate Pearson's product-movement correlation coefficients, giving a collection of variables for inclusion into a stepwise multiple regression model. Five-and-a-half percent of the variance in ball velocity was explained by the multiple regression model containing the sequential timing variables of thoracic linear kinetic energy (KE), upper-arm circumduction velocity, and forearm rotation KE, as well as the pelvic-shoulder separation acceleration (R 2 = 0.55, adjusted R 2 = 0.49, F(4, 29) = 8.86, p 0.001). In order to create ball speed in fast bowling, this study shown that both the intensity and timing of segmental activation are crucially required.

Worthington, Peter et al., (2012) The researchers set out to find out what makes the quickest bowlers tick in terms of technique. Eleven kinematic factors, characterizing aspects of fast bowling technique that have been connected to ball release speed, were derived based on kinematic data obtained from 20 elite male fast bowlers. The greatest amount of variance in ball release speed (74%) can be accounted for by changes to just four technique factors. Faster bowlers were shown to have a shorter run-up and a more straightened knee during the front foot contact phase. It was also found that the quickest bowlers exhibited more upper trunk flexion just prior to ball release and started their arm circumduction later. The characteristics in fast bowlers' techniques that best explain their varying release speeds are isolated in this study. Both coaching and talent scouting for fast bowlers might benefit from these findings.

Ferdinands, Rene et al., (2010) Center of mass velocity estimates from kinetic studies suggest that fast bowlers can achieve run-up speeds on par with world-class javelin throwers. In this study, a three-dimensional (3-D) motion analysis system (240 Hz) was used to evaluate 34 fast bowlers (22.3 +/- 3.7 years) from premier grade level and above. Bowlers were ranked by speed into slow, medium, medium-fast, and rapid categories. Back foot contact (run-up speed) averaged 5.3 +/- 0.6 m/s in terms of center of mass velocity. The two quicker bowling groups had considerably higher centre of mass velocities at rear foot impact than the slow to medium bowling group. Furthermore, the centre of mass deceleration across the delivery stride phase was the best predictor of ball speed in the quicker bowling groups, as shown by stepwise multiple regression analysis. Fast bowlers' ability to generate ball speed is, in large part, determined by the kinematics of their centre of mass. In example, it may be easier to create high ball speed for those bowlers who can time their motion with times of centre of mass deceleration.

III. RESEARCH METHODOLOGY

The Indian women's cricket team's top five fast bowlers were videotaped with two 125 Hz synchronized cameras. In order to measure run up speeds, five sets of timing gates were installed every three meters along the run up. Each bowler had their quickest delivery from two simulated

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overs of a match analyzed in three dimensions. The joint centers were manually digitized, and the 3D reconstruction was processed using AP ASTM motion analysis software (Ariel Dynamics Inc., USA).

The angles of the shoulder and hip segments were determined by projecting onto the transverse plane a line linking the centers of the respective joints. Figure 1 shows the results of an evaluation of the orientation of these lines in relation to a line drawn down the pitch between the stumps.

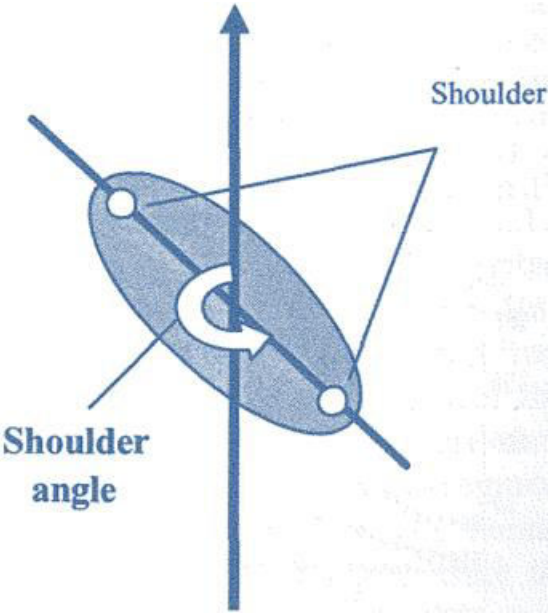

Figure 1: Calculation of shoulder angle

Bowlers were then categorized based on their shoulder posture during back foot contact (BFC) using a system adapted from Burnett et al. (1995) and Portus et al. (2000). Shoulder angle less than 210 degrees at base of skull. Shoulders turned inward at BFC more than 210 degrees when seen head-on. A shoulder counter rotation of more than 40 degrees or a hip-shoulder separation angle of 20 degrees or more at BFC indicates a mixed pattern.

IV. DATA ANALYSIS AND INTERPRETATION

This study found that female bowlers had a mean run up speed of 4.9ms-1, suggesting that their approach speeds were similar to or slightly slower than those reported for male bowlers. In comparison to senior male bowlers, this group had a slower average ball release speed of 27 ms-1. In this sample of fast pitchers, the average BFC shoulder angle was 222 degrees. Shoulder counter rotation occurred after BFC, with a 193° shoulder angle being the average minimum.

Table 1: Hip and shoulder orientation (°) during fast bowling

Subject	Hip angle	Shoulder angle	Separation angle	Min-Shoulder angle	Shoulder counter rotation	Max. ball Velocity (ms-1)
A	260	235	-28	199	34	30
B	215	229	13	187	40	28
C	208	209	4	200	11	23.6
D	211	223	12	183	40	25.4
E	218	220	-1	196	22	27.8
Mean	222	222	0	193	29	27
S.d.	22	8.4	16.8	7.8	12.6	2.5

*at BFC

Two of the bowlers were labeled as front-on after being evaluated against the technique categorization criteria. Three other bowlers fell into the "mixed" category because one had a hip-shoulder separation angle of more than 20 degrees at BFC while another had a shoulder counter rotation of more than 40 degrees after BFC. In this analysis, no bowlers were categorized as adopting the side-on approach.

V. CONCLUSION

In order to better understand the sport and aid in the cultivation of future female cricket stars, kinematic analysis of fast bowling tactics utilized by elite female

cricketers is essential. The cricket community may help advance gender equality and encourage the development of female fast bowlers by implementing the results and suggestions from this study. Large hip-shoulder separation angles and counter rotation of the shoulders for some of these female bowlers suggests they may have adopted techniques previously linked with back injuries in male fast bowlers, though the numbers reported for'shoulder and hip segment orientation in this study are not meant to be definitive in terms of spinal mechanics.

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