JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

KINEMATIC ANALYSIS OF SELECTED BAT SWING METRICS AND BODY KINEMATIC VARIABLES ON EXECUTION OF COVER DRIVE IN CRICKET

Mr. D. Sujinraj[a] & Dr. M. Rajkumar[b]

[a] Research scholar, Department of Physical Education, Bharathiar University-Coimbatore.
[b] Professor and Head, Department of Physical Education, Bharathiar University- Coimbatore

Abstract

Objective and aim of this study: The objective of this study was to examine the relationship between kinematic analysis of selected bat swing metrics and body kinematic variables on execution of cover drive in cricket.

Participation: Ten male university-level cricketers (Age: 20.60 ± 0.8 years, Height: 170.70 ± 4.7 cm, Weight: 65.90 ± 4.8 kg) were selected from the Department of Physical Education, Bharathiar University, Coimbatore, Tamil Nadu-641046, India.

Methods and measures: The performance variable examined in this study was the cover drive and technique of the subjects on cover drive in batting was collected on the basis of the judge evaluation. Alongside selected bat swing metrics, such as Back lift angle, downswing angle, Bat face angle and follow through angle. Data collection utilized the latest version of the Stance Beam smart cricket bat sensor for analytic protocols. Additionally, body kinematic variables such stance width (distance between front foot and back foot), Right elbow angle, Left elbow angle, Right knee angle, Left knee angle, Front ankle angle and Back ankle angle were analysed. During data collection, two-dimensional (2D) videography was performed, and the recorded videos were analysed and finalized using Kinovea software as the filming and analysis protocol. Performance skill was assessed using a standardized scoring system.

Statistical technique: Descriptive statistics and Pearson coefficient correlation ('r') statistics are used at 0.05 level of significance to analyse a correlation between the variables. The study's findings did correspond to the hypothesis formulation.

Result: The results showed that selected bat swing metrics and body kinematic variables are significantly interrelated; however, their direct relationship with cover drive performance was found to be insignificant. Coaches and players are encouraged to focus on comprehensive biomechanical analysis and integrated training approaches to develop these aspects, aiming to achieve technical excellence in cricket batting.

Keywords: ***Stance beam smart cricket bat sensor, Kinovea software, Body Kinematic variables, bat swing metric and cricket players.***

Introduction

Cricket is a sport that demands a combination of skill, technique, and precision. Among the various batting strokes, the cover drive is one of the most elegant and technically demanding shots, requiring proper coordination of speed and angular kinematic movements. A well-executed cover drive involves the optimal positioning of the bat, correct timing, and efficient energy transfer to the ball. Among the various batting strokes, the cover drive is considered one of the most technically refined shots, requiring a well-coordinated movement between the bat, hands, and lower body (***Bartlett et al., 2006***). Proper execution of the cover drive depends on several biomechanical factors, including bat speed, bat lift angle, downswing angle, bat face angle, and follow-through angle, all of which influence the timing, accuracy, and power of the shot (***Glazier, 2010***). In recent years, sports technology has played a significant role in enhancing cricket performance analysis. IoT based devices embedded in cricket bats and wearable trackers on players capture real-time data on bat swing speed, foot movement, fitness levels, and field positioning. Devices such as the StanceBeam Smart Cricket Bat Sensor provide real-time feedback on key kinematic variables, allowing researchers and coaches to assess and improve batting techniques (***Chaudhari et al., 2019***). With advancements in sports technology, analyzing biomechanical aspects of cricket shots has become more precise. The ***StanceBeam Smart Cricket Bat Sensor*** is a cutting-edge tool that helps measure key performance variables such as bat speed, bat angles, and shot efficiency. Understanding the relationship between these kinematic variables and shot execution can provide valuable insights for coaches and players to refine their technique and enhance performance. Advanced video processing and neural networks help generate automatic highlights, summarize videos, and analyze umpire actions and player movements. ***Kinovea 2025.1.0*** is a free, open-source 2D motion analysis software designed for analyzing, comparing, and evaluating movement in sports, clinical, and research settings. It functions as a powerful video annotation tool, allowing users to extract objective, quantitative data from video recordings. ***(Joan Charmant, 2004)*** .The study presented in this paper examines whether Kinovea software is reliable to analyse the kinematic movement of cricket players. The analysis will be done by using motion capture software Kinovea. Kinovea is primarily used for biomechanical and kinematic analysis of human movement, enabling users to study and evaluate performance in sports or monitor progress in rehabilitation.

Methods and measures

Participation: : Ten male university-level cricketers (Age: 20.60 ± 0.8 years, Height: 170.70 ± 4.7 cm, Weight: 65.90 ± 4.8 kg) were selected from the Department of Physical Education, Bharathiar University, Coimbatore, Tamil Nadu-641046, India.

Methods and measures: The performance variable examined in this study was the cover drive and technique of the subjects on cover drive shot in batting was collected on the basis of the judge evaluation. Alongside selected bat swing metrics, including maximum bat speed, bat speed at impact, power generated, back lift angle, downswing angle, follow-through angle, time to impact, back lift direction angle, downswing direction angle, and bat face angle. Data collection utilized the latest version of the Stance Beam smart cricket bat sensor for analytic protocols. Additionally, kinematic variables such as the distance between the legs during stance, centre of gravity, foot position during back lift and backswing, head position, elbow angle, knee angle, and ankle angle were analysed. During data collection, two-dimensional (2D) videography was performed, and the recorded videos were analysed and finalized using Kinovea software as the filming and analysis protocol. Performance skill was assessed using a standardized scoring system.

Instrumentations

The **Stance Beam Striker** was used as the primary data collection instrument. The "Stance Beam Striker" is the industry's most accurate Cricket Bat sensor. Designed to fit on top of any cricket bat and connect wirelessly to a mobile app. Stance Beam Striker is designed to provide you with real-time feedback and insights on your Bat Swing, Bat Speed, Bat Angles Power and Shot Efficiency. The data collected by the sensor can be viewed on the StanceBeam app in real-time and is stored on the cloud. It comes with Replaceable Bat Mounts for easy installation on any cricket bat and a locking key to make sure that the Striker remains locked securely inside the Bat Mount.

Kinovea Software (Version 2025.1.0)

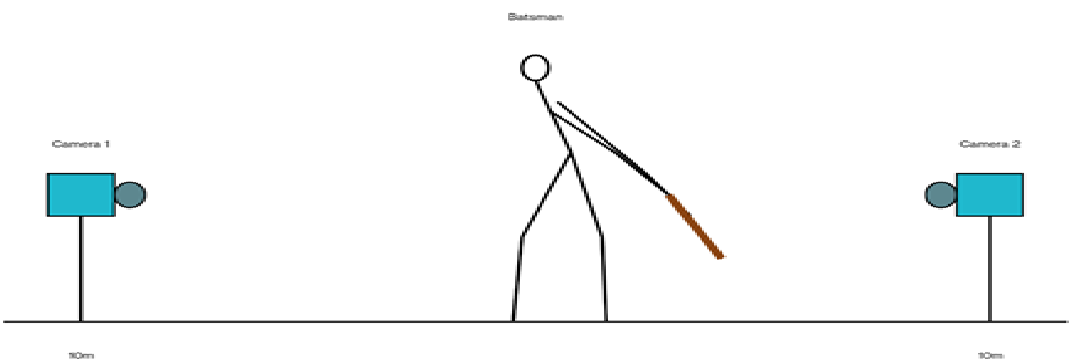
To measure using Kinovea, first import a video of the motion to be analyzed. Calibration is performed using a known reference length within the video for accurate scaling. Users then mark points on the video frame-by-frame to track movement, angles, distances, or speeds. Kinovea calculates these metrics automatically based on the calibration. The output includes numerical data on distances, angles, velocities, and timings, along with annotated videos and graphs. This data helps in performance analysis, technique correction, and injury prevention. The output can be exported as CSV files for detailed review and reporting.

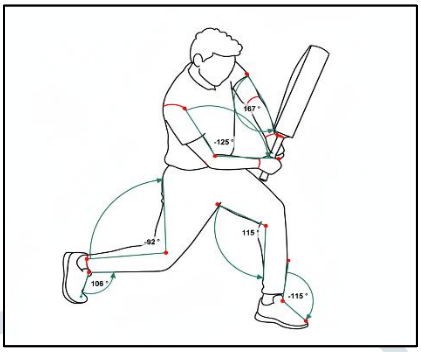
Procedures

Participants underwent a standardized warm-up routine before testing. The Stance Beam Striker was mounted securely on each player's bat using the replaceable bat mount and locking key provided with the device. After proper calibration, players performed a series of pre-determined cricket shots, including drives, cuts, and pull shots, under controlled conditions. Each shot was recorded and analysed using the Stance Beam mobile application.

Filming protocol and analysis:

The video was taken by a professional photographer who is considered an expert in this area. The subject was filmed only in the sagittal plane. After the loading of the video, images were shot by pausing the video at the desired time using the Kinovea software. The camera was set at 0.85 metres above ground level, and the horizontal distance of the camera was 10 metres. The two-meter reference line was drawn for calibration. Based on the videography obtained by the researcher, the researcher improvised the stick figures in which data about various kinematic variables were taken.





Statistical technique: Descriptive statistical and Pearson coefficient correlation ('r') statistics analyses were conducted using "SPSS software" with a significance level set at $p < 0.05$. Data was compared across different playing levels to assess the impact of biomechanical efficiency on shot execution.

Result and discussion

Table 1 show the value of Descriptive Statistics of execution of cover drive

Variables	*N*	*Mean*	*Std. Deviation*
Performance (cover drive)	10	8.8000	1.39841
Stance width (distance between front foot and back foot)	10	65.1100	6.22155
Right elbow angle	10	139.9500	4.41544
Left elbow angle	10	156.6300	3.99195
Right knee angle	10	156.4200	3.62975
Left knee angle	10	147.6600	3.72654
Front ankle angle	10	84.6700	3.69836
Back ankle angle	10	91.1500	2.15780
Back lift angle	10	60.0300	4.71170
Downswing angle	10	43.8200	2.75310
Follow through angle	10	76.3200	4.81567
Bat face angle	10	3.5500	1.51383

Table 2 show the value of execution of cover drive correlations 'r' statistics to find out the relationship between the cover drive performances, body kinematic and bat swing metrics

variable pair-execution of cover drive	*(r)*
Stance width – Right elbow	0.998*
Stance width – left elbow	0.994*
Stance width – right knee	0.995*
Stance width – left knee	-0.995*
Stance width – front ankle	-0.996*
Stance width – back ankle	0.990*
Stance width – backlift	0.998*
Stance width – downswing	-0.994*
Stance width – follow through	0.997*
Stance width – bat face	-0.981*

*Significant Correlations ($p \leq 0.01$)

Table 2 presents the correlation coefficients ('r' values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The results indicate that stance width is highly and significantly correlated with multiple movement variables, including right elbow (r = 0.998*), left elbow (r = 0.994*), right knee (r = 0.995*), and backlift (r = 0.998*), showing positive associations. Conversely, stance width has strong negative correlations with left knee (r = -0.995*), front ankle (r = -0.996*), downswing (r = -0.994*), and bat face angle (r = -0.981*), suggesting that as stance width increases, these specific joint positions and bat angles decrease. The correlation with back ankle (r = 0.990*) and follow through (r = 0.997*) also demonstrates significant positive relationships.

Table 3- variable pair- Execution of cover drive	*(r)*
Right elbow – Right Knee	0.994*
Right elbow – left knee	-0.997*
Right elbow – front ankle	-0.996*
Right elbow – back ankle	0.991*
Right elbow – backlift	0.998*
Right elbow – downswing	-0.993*
Right elbow – follwothrough	0.996*
Right elbow – bat face	-0.983*

*Significant Correlations ($p \leq 0.01$)

Table 3 show the correlation coefficients (‘r’ values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The right elbow shows strong and significant correlations with selected body kinematic and bat swing metrics. It is highly positively correlated with the right knee (r = 0.994*), back ankle (r = 0.991*), back lift (r = 0.998*), and follow-through (r = 0.996*). Conversely, the right elbow exhibits strong negative correlations with the left knee (r = -0.997*), front ankle (r = -0.996*), downswing (r = -0.993*), and bat face angle (r = -0.983*).

Table 4- variable pair - Execution of cover drive	*(r)*
Left elbow – left knee	-0.998*
Left elbow – front ankle	-0.993*
Left elbow – back ankle	0.994*
Left elbow – backlift	0.996*
Left elbow – downswing	-0.993*
Left elbow – follwothrough	0.993*
Left elbow – bat face	-0.985*

*Significant Correlations ($p \leq 0.01$)

Table 4 show the correlation coefficients (‘r’ values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The left elbow exhibits a very strong negative correlation with the left knee (r = -0.998*), front ankle (r = -0.993*), and downswing (r = -0.993*). On the other hand, it has strong positive correlations with the back ankle (r = 0.994*), backlift (r = 0.996*), and follow-through (r = 0.993*). Additionally, the left elbow shows a significant negative correlation with the bat face angle (r = -0.985*).

Table 5- variable pair - Execution of cover drive	*(r)*
Right Knee – front ankle	-0.998*
Right Knee – back ankle	0.997*
Right Knee – backlift	0.997*
Right Knee – downswing	-0.998*
Right Knee – follwothrough	0.992*
Right Knee – bat face	-0.991*
Left knee – front ankle	0.996*

*Significant Correlations ($p \leq 0.01$)

The table 5 show the correlation coefficients (‘r’ values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The right knee shows strong negative correlations with the front ankle (r = -0.998*) and downswing (r = -0.998*). It also exhibits strong positive correlations with the back ankle (r = 0.997*), backlift (r = 0.997*), and follow-through (r = 0.992*), indicating coordinated joint actions essential for power generation and smooth execution. Additionally, the right knee is strongly negatively correlated with bat face angle (r = -0.991*), highlighting its role in influencing bat orientation through the stroke. The left knee also displays a strong positive correlation with the front ankle (r = 0.996*), emphasizing the interconnectedness of lower limb joints in stabilizing the body during the shot.

Table 6- variable pair - Execution of cover drive	*(r)*
Left knee – back lift	-0.996*
Left knee – downswing	0.993*
Left knee – follow-through	-0.990*
Left knee – bat face	0.987*

*Significant Correlations (p ≤ 0.01)

Table 6 show the correlation coefficients ('r' values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The left knee demonstrates a highly negative correlation with backlift (r = -0.996*) and follow-through (r = -0.990*). In contrast, the left knee exhibits a strong positive correlation with downswing (r = 0.993*) and bat face angle (r = 0.987*).

Table 7- variable pair - Execution of cover drive	**(r)**
Front ankle – back lift	-0.997*
Front ankle – downswing	0.997**
Front ankle – follow through	-0.992*
Front ankle – bat face	0.989*

*Significant Correlations (p ≤ 0.01)

Table 7 shows the correlation coefficients ('r' values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The front ankle has a very strong negative correlation with backlift (r = -0.997*). Conversely, it has a strong positive correlation with downswing (r = 0.997**), reflecting synchronized movement during the bat's downward trajectory. Additionally, the front ankle is negatively correlated with follow-through (r = -0.992*) and positively correlated with bat face angle (r = 0.989*).

Table 8- variable pair - Execution of cover drive	**(r)**
Back ankle – downswing	-0.993*
Back ankle – follow through	0.987*
Back ankle – bat face	-0.990*
Back lift – downswing	-0.996*
Back lift – follow through	0.998*
Back lift – bat face	-0.986*

*Significant Correlations (p ≤ 0.01)

Table 8 shows the correlation coefficients ('r' values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. The back ankle shows a strong negative correlation with the downswing (r = -0.993*) and bat face angle (r = -0.990*), and a strong positive correlation with follow-through (r = 0.987*), indicating its involvement in stabilizing and transferring force through the lower limb during the shot. The back lift is similarly negatively correlated with downswing (r = -0.996*) and bat face angle (r = -0.986*), while showing a very strong positive correlation with follow-through (r = 0.998*). These relationships highlight

Table 9- variable pair - Execution of cover drive	**(r)**
downswing – bat face	0.987*

*Significant Correlations (p ≤ 0.01)

Table 9 shows the correlation coefficients ('r' values) highlighting the relationships between selected body kinematic variables, bat swing metrics, and the performance of the cover drive in cricket. Highlights a strong and significant positive correlation between the downswing phase and the bat face angle during the execution of the cover drive (r = 0.987*).

Table 10- variable pair - Execution of cover drive	**(r)**
Follow through – bat face	-0.976*

*Significant Correlations (p ≤ 0.01)

Table 10 shows a significant negative correlation between the follow-through phase and the bat face angle during the execution of the cover drive (r = -0.976*). This suggests that as the follow-through progresses, the bat face angle decreases, indicating a coordinated adjustment in bat orientation that likely contributes to shot control and direction. The strong inverse relationship highlights the critical role of follow-through mechanics in determining the final positioning of the bat, thereby influencing the efficacy and precision of the cover drive stroke.

Table 11- variable pair - Execution of cover drive	**(r)**
Performance – stance width	0.380
Performance – Right elbow	0.371
Performance – Left elbow	0.350
Performance – right knee	0.369
Performance – left knee	-0.390
Performance – front ankle	-0.360
Performance – back ankle	0.383
Performance – backlift	0.370
Performance – downswing	-0.322
Performance – follow through	0.327
Performance – bat face	-0.388

*Insignificant Correlations ($p > 0.01$)

Table 11 presents the correlation coefficients between various execution kinematic variables and overall cover drive performance. The correlations range from weak to moderate and are statistically insignificant, with values such as stance width (r = 0.380), right elbow (0.371), left elbow (0.350), right knee (0.369), and back ankle (0.383) showing weak positive relationships with performance. Conversely, variables like left knee (r = -0.390), front ankle (-0.360), downswing (-0.322), and bat face angle (-0.388) have weak negative correlations with performance.

DISCUSSION OF FINDINGS

The finding of the study show that selected bat swing metrics, body kinametric and cover drive performance have significant relationship between during the execution of cover drive. The study finds strong positive correlations between stance width and joint angles and bat angels such as the right elbow, left elbow, right knee, back lift, and follow-through. Because that the wider stance facilitates optimal upper and lower limb synergy during the drive (stroke). Conversely, negative correlations between stance width and variables like the left knee, front ankle, downswing, and bat face indicate that narrower stance or specific joint flexion patterns may favour certain aspects of stroke mechanics, such as bat angle and swing path. The execution of the cover drive involves a coordinated relationship between lower body positioning, upper limb angles, and bat swing mechanics, emphasizing the importance of integrated kinematic patterns for effective stroke play. The study related with other study ***(Penn and Spratford, 2012)*** in their systematic review noted that a stance width similar to shoulder-width is recommended, with emphasis on allowing quick forward or backward movement. Research indicates wider stances may optimize stability by increasing base of support but can reduce mobility. The right and left elbows exhibit strong bilateral coordination with knee, ankle, and bat swing phases. The right elbow's show high positive correlation with the right knee and back ankle, along with negative correlations with the left knee and front ankle, suggest a bidirectional relationship that supports balanced weight transfer and bat control. The opposing joint and swing phase interactions crucial for balanced and effective stroke execution. These findings emphasize the integral role of right elbow mechanics in facilitating a coordinated kinetic chain essential for performing a technically proficient cover drive. Similar tendencies are observed with the left elbow, highlighting the importance of limb synchronization in stroke (drive) accuracy and power generation. The critical coordination between the back ankle and back lift phases in delivering power, controlling bat trajectory, and ensuring fluid follow-through during the cover drive, emphasizing their key biomechanical roles in executing an effective cricket stroke. This indicates that the movement during the downswing is closely associated with the orientation of the bat face, suggesting coordinated control of bat trajectory and positioning at the critical moment of ball impact. The synchronization between downswing and bat face angle plays a vital role in ensuring precision and effectiveness of the cover drive stroke. The related study conducted by ***(McErlain-Naylor, Harland, and King 2019)*** in Human Movement Science demonstrated that specific kinematic parameters are critical for batting performance. That greater flexion or positioning of the left knee is associated with reduced back lift and follow-through magnitudes during the shot. Joint-level interaction analysis reveals that the knee and ankle joints are crucial, with strong negative correlations between the knee and ankle segments, indicating that the opposing motions of these joints contribute significantly to stability and control during the swing. Left knee motion is closely linked to the downward trajectory of the bat and its orientation at impact. These relationships emphasize the critical contribution of the left knee in controlling both the preparatory and terminal phases of bat swing mechanics, which are essential for achieving technical proficiency and balance in the cover drive. ***(Rao et al., 2024)*** The high correlation between the downswing and bat face angle further underscores the importance of precise timing and angle control during the execution phase, as discussed by ***(Patel and Singh 2021).*** Individual variables of selected bat swing matric and body kinematic variables showed insignificant correlations with overall performance, implying that technical success in cover drive execution relies on a complex interaction of multiple biomechanical factors rather than isolated joint positions or movements. This finding aligns with prior research indicating that stroke effectiveness depends on the coordination and timing of multiple kinetic chains rather than single joint contributions. These results suggest that individual biomechanical variables during execution, although strongly interrelated among themselves, do not alone predict the outcome or effectiveness of the cover drive shot, indicating that other factors likely contribute to performance outcomes Similar kind of study is conducted by ***(Stuelcken, Portus, and Mason 2005)*** in Sports Biomechanics analyzed off-side front foot drives in elite cricketers, demonstrating coordinated movement patterns essential for stroke production. ***(Pulen Das, 2023).***

Conclusion

The study concluded that the execution of the cover drive in cricket depends on a complex integration of multiple biomechanical factors. The concluded that the strong interrelationships between selected bat swing metrics and body kinematics with stance width playing a key role in optimizing upper and lower limb synergy. Despite significant interactions among these variables, individual kinematic measures alone do not directly predict overall performance, emphasizing the importance of coordinated movement patterns and timing. The study underscores that technical excellence in the cover drive arises from synchronized kinetic chain actions, including the coordinated roles of the elbows, knees, ankles, backlift, and downswing phases. Coaches and players are encouraged to emphasize holistic biomechanical training that integrates these factors for optimal stroke play, aligning with prior research on cricket batting biomechanics.

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