Analyze the Delivery Stride to Enhance the Speed and Accuracy of Fast Bowlers

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Publication Date: 2025/12/22

Abstract: Fast bowlers are integral to cricket, their capacity to produce speed and precision being vital for team triumph. This study was aimed to analyze the performance of the delivery stride in cricket fast bowlers with the objective of refining their speed and accuracy. The data was collected from four (n=04) male medium fast bowler premier level cricketers in Sri Lanka. The delivery stride, encompassing hip rotation, arm action, and foot placement during ball delivery, was captured by using 02 high-speed cameras (100Hz). The space calibration was completed from frontal and sagittal planes, separately. Human movement 2D analyzing software (Kinovea 0.9.3) was used to analyze for each frame of delivery stride. The correlation of speed and accuracy to the delivery stride was analyzed by the person correlation. Furthermore, speed and accuracy data were collated from the players, with ball speeds ranging from 100 kmph to 120 kmph and average accuracy scores varying from 7 to 10. It was observed that accuracy increases with a high delivery stride but decreases with an excessive stride and high delivery stride enhances bowling speed. In linear kinematics motion, it was deduced that the stride is directly proportional to variables such as Horizontal Velocity (r = 0.74), Speed (r = 0.81), Total Distance (r = 0.72), while inversely proportional to Vertical Acceleration (r = - 0.55). Similarly, in angular kinematics motion, it was concluded that the stride is directly proportional to Angular Acceleration (r = 0.63). Additionally, in lateral pelvic tilt motion, it was observed that the stride is directly proportional to the pelvic motion Angle (r = 0.63), while somewhat inversely proportional to Angular Velocity (r = -0.47). Therefore, the better utilization of momentum and body mechanics can significantly enhance the speed of the ball and the accuracy of bowling. In conclusion, optimizing the delivery stride can elevate fast bowlers into more potent assets contributing to success on the cricket field.

Keywords: *Cricket, Delivery Stride, Medium Fast Bowler, Performance.*

How to Cite: J. P. S. Jayaneththi; A. W. S. Chandana (2025) Analyze the Delivery Stride to Enhance the Speed and Accuracy of Fast Bowlers. *International Journal of Innovative Science and ResearchTechnology,*10(12), 1248-1261. https://doi.org/10.38124/ijisrt/25dec740

I. INTRODUCTION

Fast bowling has been a focal point of research in cricket in recent decades, attracting significant attention due to its key role in shaping match outcomes and player performance. This enduring interest underscores ongoing efforts to understand and improve the techniques and strategies used by fast bowlers. (Ramachandran et al., 2021). In cricket fast bowling, the speed with which the bowler releases it profoundly affects the outcome of the delivery. A high release speed reduces the batsman's window for making decisions and executing strokes, thereby limiting the runs scored or increasing the chance of the batsman being dismissed. In cricket, delivery refers to the delivery of the ball by the bowler to the batsman facing the delivery. Generally, there are six balls in an over, and a predetermined number of overs constitute a one-day match or match. Fast bowlers are broadly classified into two categories: fast bowlers and medium bowlers. Cricket bowling performance stands out due to its ability to integrate various demanding physical activities with mechanical applications, offering an intriguing blend of athleticism and technical skill. (Khan, Scholar, et al., 2020). Traditionally, the period from back foot impact to ball release delineates the delivery stride. About 70% of this phase is marked by front-foot impact, leaving the remaining 30% crucial for generating the energy and momentum necessary for a forceful ball release. This momentum is primarily unleashed through the eccentric contraction of trunk rotators induced by hip rotation. The elastic energy accrued during this phase aids in amplifying concentric contraction, thereby augmenting the angular velocities of the thorax and distal body segments within the upper extremity segment system. Understanding and optimizing these mechanisms can significantly impact a bowler's ability to generate speed and accuracy, thus enhancing their overall effectiveness on the cricket field. (Glazier & Wheat, 2014a).

➢ *Research Problem*

To an analysis of the delivery stride significantly contributes to enhancing both the speed and accuracy of fast bowling among Sabaragamuwa University bowlers. By

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

meticulously scrutinizing the mechanics of the delivery stride, athletes can identify and rectify inefficiencies, thereby optimizing their technique to generate greater velocity and precision in their bowling actions. This comprehensive examination empowers bowlers to fine-tune their movements, ultimately translating into tangible improvements in their fast-bowling performance.

(Delivery strike: - focusing on foot placement, Lateral pelvic tilt motion, arm action)

- *Medium Fast Bowlers*

Medium-fast bowling in cricket refers to a style of bowling where the bowler delivers the ball at a pace slower than that of a fast bowler but faster than a medium-paced or spin bowler. Medium-fast bowlers typically aim to generate considerable pace and bounce while also focusing on accuracy and movement off the pitch. They often rely on a combination of seam and swing to deceive batsmen and take wickets (Determinants of Ball Release Speed in Schoolboy Fast-Medium Bowlers in Cricket, n.d.-a). Medium-fast bowlers use a shorter run- up compared to fast bowlers but still generate significant speed through a powerful action involving coordinated movements of the arms, legs, and torso. Their deliveries can vary in terms of length, line, and movement, making them challenging for batsmen to predict and play effectively. Overall, medium-fast bowling requires a balance between speed, accuracy, and skillful use of seam and swing to trouble batsmen and contribute effectively to the team's bowling attack. Players classified as medium-fast bowlers can play a crucial role in providing variety and depth to a team's bowling lineup across different formats of the game (Burden & Bartlett, n.d.). Medium-fast bowling in cricket is a style of bowling that combines elements of both fast and medium pace. Bowlers in this category typically deliver the ball at speeds ranging from 70 to 80 miles per hour (115-130 km/h). Medium-fast bowlers rely on a balance between pace and accuracy to unsettle batsmen and take wickets. One of the key characteristics of medium-fast bowling is the ability to generate enough pace to trouble batsmen while also maintaining control over line and length. These bowlers often possess a smooth, rhythmic bowling action that allows them to maintain consistency in their deliveries. Unlike outright fast bowlers who rely solely on speed, medium-fast bowlers focus on exploiting any movement available on the pitch, whether it be swing, seam, or bounce. Medium-fast bowlers are adept at swinging the ball both ways through the air, making them a constant threat to batsmen. They can achieve swing by imparting either conventional or reverse swing on the ball, depending on the condition of the ball and the pitch. Additionally, medium-fast bowlers are skilled at bowling cutters and variations in pace to deceive batsmen (Phillips et al., 2012a). Accuracy is paramount for medium-fast bowlers, as they often rely on subtle variations in line and length to create pressure on batsmen and induce mistakes. By consistently hitting the right areas on the pitch, they force batsmen into defensive strokes or induce edges that can lead to dismissals. The training and competition requirements for medium-fast bowlers typically entail enduring multiple and extended spells over consecutive days (Minett et al., 2012). The bulk of scientific inquiry regarding the biomechanics of men's cricket has predominantly cantered on the techniques involved in fast or fast-medium bowling. Success in fast bowling is contingent upon a multitude of factors, with one pivotal element being the velocity of the ball at release (McNamara et al., 2017). A rapid release speed diminishes the batsman's window for perceiving and reacting to the delivery. Achieving high release speeds necessitates the bowler's trunk to execute rapid flexion, extension, lateral flexion, and rotation within a compressed timeframe, while concurrently managing ground reaction forces that can exceed six times the body weight.

- *Delivery Stride*

The term "delivery stride" refers to the phase during the bowling action when the ball is delivered or released. According to the Marylebone Cricket Club (MCC) guidelines from 1976, the delivery stride begins at the moment of back foot strike, where the weight should predominantly be on the back foot, and the body should lean away from the batsman. Three key events delineate the delivery stride: back foot strike, front foot strike, and ball release. When discussing angles related to the back foot and the alignment of hips and shoulders, reference is made to the direction indicated by specific lines: from the heel through the center of the back foot (midline of the foot), from left to right hip (hip alignment), and from left to right shoulder (shoulder alignment). Angles are determined by measuring, in an anti- clockwise direction, the angle between the "zero line" and the midline of the foot, as well as the hip and shoulder alignments. These angular measurements provide valuable insights into the biomechanics of the delivery stride, offering a quantitative understanding of the alignment and positioning crucial for effective bowling technique. (Bartlett et al., 1996a).

- *Arm Action*

Fast bowling arm action in cricket is a critical aspect of a bowler's technique, dictating the speed, accuracy, and movement of their deliveries. The arm action refers to the motion of the bowling arm during the delivery stride, encompassing the movement from the backswing to the release of the ball (Salman et al., 2017). A typical fast bowling arm action involves a series of coordinated movements designed to generate maximum speed and control over the ball. It begins with the bowler's run-up, during which they build momentum by sprinting towards the crease. As they approach the delivery stride, the bowler's non-bowling arm swings back to provide balance and counter-rotation, while the bowling arm comes up and over in a fluid motion (R. E. D. Ferdinands & Kersting, 2007). At the point of release, the fast bowler's arm extends fully towards the target, with the wrist and fingers behind the ball to impart spin or seam movement. The elbow of the bowling arm should be close to fully extended but not completely locked, ensuring a legal delivery and minimizing stress on the arm (Goonetilleke, 1999). The speed of the arm action is crucial for generating pace, with faster movements resulting in greater velocity on the ball. However, control and accuracy are equally important, requiring bowlers to

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

maintain a consistent and repeatable arm action throughout their spell. A well-executed fast bowling arm action enables bowlers to generate swing, seam movement, or bounce depending on the conditions and type of delivery. It is a combination of strength, flexibility, and coordination honed through practice and coaching, allowing fast bowlers to consistently challenge batsmen and contribute to their team's success (Portus et al., 2006a).

- *Foot Placement*

Fast bowling foot placement in cricket is a fundamental aspect of a bowler's technique, crucial for generating power, balance, and accuracy during the delivery stride. It involves the positioning and movement of the feet in the run-up and delivery stride, which directly impact the effectiveness of the bowling action and the outcome of the delivery (R. Ferdinands et al., 2010). During the delivery stride, the front foot plays a critical role in providing stability and facilitating the transfer of weight. As the bowler strides forward towards the popping crease, the front foot lands on the ground with the toes pointing towards the target. This action not only provides a stable base for the delivery but also helps in aligning the body towards the intended direction of the ball. Simultaneously, the back foot follows through by pivoting on the ball of the foot, aiding in generating rotational force and momentum (Stuelcken et al., 2005). The back foot should land alongside or slightly behind the front foot, ensuring a smooth and coordinated delivery stride. Proper foot placement allows fast bowlers to generate maximum power and control over their deliveries while minimizing the risk of injury. It is a skill that requires practice, coordination, and attention to detail, contributing significantly to the effectiveness and success of a fast bowler on the cricket field (Glazier & Wheat, 2014b).

Lateral Pelvic Tilt Motion

Fast bowling hip rotation in cricket involves the pivotal movement of the hips during the delivery stride. As the bowler approaches the crease, the hips rotate open towards the batsman, generating torque and transferring energy from the lower body to the upper body. This rotational force amplifies the power of the delivery, allowing fast bowlers to generate greater speed and momentum. Proper hip rotation also helps in maintaining balance and alignment, enabling bowlers to deliver the ball with accuracy and efficiency. It's a critical component of the fast-bowling action, contributing significantly to the effectiveness of the delivery (Senington et al., 2018). Hip and pelvic motion play a crucial role in the finger spin bowling action, contributing significantly to the overall effectiveness and mechanics of the delivery (Sanders et al., 2019). However, no studies have reported the rotational PROM (Passive Range of Motion) in elite finger spin bowlers. Research examining hip rotation PROM in baseball has yielded conflicting results. While some studies have observed greater internal rotation and reduced external rotation PROM in the stance leg compared to the stride leg, others have found no discernible differences, (Beach et al., 2018) others have found no differences (Tippett, 1986).

- *Speed and Accuracy*

Fast bowling in cricket relies on a delicate balance between speed and accuracy. Speed refers to the velocity at which the ball is delivered, often exceeding 90 miles per hour (145 km/h) for elite fast bowlers. It is a crucial weapon for intimidating batsmen, inducing mistakes, and taking wickets through sheer pace. However, speed alone is not enough; accuracy is equally important. Accuracy involves consistently hitting the desired line and length on the pitch, placing the ball in areas that trouble batsmen and create wicket-taking opportunities (Phillips et al., 2012b). A combination of speed and accuracy allows fast bowlers to maintain pressure on batsmen, forcing them into defensive strokes and capitalizing on any weaknesses. Achieving both requires not only physical strength and technique but also mental focus and discipline. Fast bowlers who can consistently bowl with both speed and accuracy are formidable assets to their teams, capable of turning matches in their Favor with their skill and precision (Determinants of Ball Release Speed in Schoolboy Fast-Medium Bowlers in Cricket, n.d.). In cricket fast bowling, the speed at which the bowler releases the ball significantly impacts the delivery's outcome. A higher release speed diminishes the batsman's window for decision- making and executing strokes, thereby curbing the runs scored or heightening the likelihood of dismissing the batsman. Training methods such as modified-implement training, involving the use of underweight and overweight implements, are acknowledged techniques for enhancing release speed in throwing sports. By practicing with these specialized implements, bowlers can improve their ability to generate greater velocity upon release, thereby bolstering their effectiveness in delivering challenging and impactful deliveries on the cricket pitch (Petersen et al., 2004). Although modified-implement training is occasionally employed by cricket fast bowlers, Petersen and colleagues discovered that a 10-week program involving training with modified balls failed to yield an increase in bowling speed among male club-level cricketers. (Petersen et al., 2004) (Wickington & Linthorne, 2017).

This research revealed that while variables utilized to categorize fast bowling actions manifested between back foot impact and front foot impact, the movements most conducive to determining the type of bowling action predominantly occurred within this timeframe. This critical period encompasses the transition from the back foot to the front foot, where the distinctive characteristics of various bowling actions become discernible. By focusing on this interval, researchers can effectively identify and analyze the key biomechanical elements that differentiate between different types of fast bowling techniques. This targeted approach facilitates a deeper understanding of the mechanics underlying fast bowling actions, aiding in the refinement and optimization of bowlers' performance. (Ranson et al., 2008a). In cricket, the bowling stride is a multifaceted technique employed to deliver the ball to the batsman. It encompasses crucial components including the run-up, hip rotation, foot placement, and arm action. Their research revealed that while variables utilized to categorize fast bowling actions manifested between back foot impact and front foot impact, the movements most conducive to determining the type of bowling action predominantly occurred within this timeframe. This critical period encompasses the transition from the back foot to the front foot, where the distinctive characteristics of various bowling actions become discernible. By focusing on this interval, researchers can effectively identify and analyze the key biomechanical elements that differentiate between different types of fast bowling techniques. This targeted approach facilitates a deeper understanding of the mechanics underlying fast bowling actions, aiding in the refinement and optimization of bowlers' performance. (Ranson et al., 2008a). In cricket, the bowling stride is a multifaceted technique employed to deliver the ball to the batsman. It encompasses crucial components including the run-up, hip rotation, foot placement, and arm action. Through adept manipulation of these elements, a bowler can significantly enhance both accuracy and speed. Each component plays a pivotal role in the execution of a successful delivery, with the run-up providing momentum, hip rotation generating power, precise foot placement ensuring balance, and efficient arm action imparting velocity to the ball. Mastery of these components enables bowlers to deliver deliveries that are both precise and formidable, challenging batsmen effectively.

Cricket is a captivating sport contested between two teams and played across three distinct formats: T20, ODI, and Test. T20 matches are fast-paced encounters, limited to 20 overs per team, fostering quick and dynamic gameplay. ODIs, characterized by fifty overs per side, offer a balance between speed and endurance, allowing teams to strategize over a longer duration. Test cricket, the pinnacle of the sport, spans five days, affording each team two innings and restricting play to 90 overs per day, showcasing the ultimate test of skill, stamina, and mental fortitude. Within these formats, players are categorized as batters, bowlers, wicketkeepers, and fielders, each playing a vital role in the team's success. Batters aim to score runs, bowlers strive to dismiss opponents, wicketkeepers maintain vigilance behind the stumps, and fielders exhibit athleticism and precision in the field. Collectively, these players contribute to the rich tapestry of cricket, showcasing their diverse talents and skills in pursuit of victory for their respective teams. (ICC Men's One Day International Playing Conditions, n.d.).

Cricket is often perceived as a sport where individual duels between batsmen and bowlers take precedence over team dynamics. While extensive research has focused on batting and bowling techniques, comparatively less attention has been devoted to the role of fielders and overall team dynamics. England, from June 14 to 17, 1999. While comprehensive reviews of batting and bowling have been prevalent, there's a growing recognition of the need to delve deeper into the nuances of fielding strategies and team dynamics. By bridging this gap in research, a more holistic understanding of the sport can be achieved, encompassing all facets of player performance and team coordination (Stretch et al., 2000), bowling (Bartlett et al., 1996a) and preventing cricket injuries already exist (Finch et al., n.d.). This review will synthesize recent research findings while also referencing earlier studies to provide context. It will explore various aspects, including the physiological and psychological demands of cricket, preparations for the game, biomechanics and motor control of cricket skills, team dynamics psychology, performance analysis, and cricket-related injuries. Additionally, technological advancements in cricket equipment will be discussed, especially if they impact injury prevention or player performance.

Driven by a commitment to improve performance and mitigate injuries, medium fast bowler premier level cricketers in Sri Lanka initiated an in-depth examination of their delivery stride. The primary objective is to enhance the precision and velocity of their fast-bowling abilities. This comprehensive analysis reflects their dedication to honing their craft and optimizing their technique on the cricket field. By scrutinizing the intricacies of their delivery stride, these bowlers aspire to attain greater effectiveness and efficiency in delivering the ball, thereby supporting their overall contribution to their team's success. Recognizing the pivotal role of a fast bowler's delivery stride in securing wickets and bolstering team success, this research is dedicated to tackling the enduring challenge faced by fast bowlers: maintaining precision while delivering the ball at high speeds. By meticulously refining the mechanics of the delivery stride, bowlers can simultaneously enhance accuracy and increase velocity. This dual improvement amplifies their potential to claim more wickets and curtail the opposition's scoring opportunities. Furthermore, optimizing the delivery stride offers a promising avenue for mitigating injury risks associated with suboptimal biomechanics, thereby promoting the longevity and well-being of the athletes. Through this concerted effort to refine technique and reduce injury susceptibility, fast bowlers aim to elevate their performance standards, ultimately making a greater impact on the cricketing stage.

The primary objective of this study is to analyze the delivery stride as a key biomechanical factor influencing medium-fast bowling performance among fast bowlers. Specifically, the study aims to evaluate the arm action during the delivery stride, examine the positioning and movement of the feet, and investigate the mechanics of lateral pelvic tilt in relation to stride execution. Furthermore, the research seeks to assess the speed and accuracy of deliveries, thereby linking biomechanical movements with bowling outcomes. By addressing these objectives, the study contributes to a deeper understanding of how stride-related biomechanical factors affect bowling efficiency, offering practical insights for coaching interventions and performance enhancement in premier level medium-fast bowlers.

II. METHODOLOGY

The research design of this study is experimental research that invents a biomechanical model in the of cricket medium fast bowlers. There selected premier level medium-fast bowlers of Sri Lanka. Before the test started, all the competitors had their anthropometric measures (height & weight) taken. Then analysis how their arm action, foot placement and hip rotation (delivery stride) components influence their speed and accuracy between each bowlers.

➤ *Study Population*

A group of premier level medium-fast bowlers in Sri Lanka, were the participants in a study that investigated the intricacies of their delivery stride. This delivery stride, the sequence of coordinated movements a bowler makes when delivering the ball, is a crucial aspect of bowling technique. It typically consists of three key components: hip rotation, which generates speed and accuracy; foot placement, which ensures balance and stability; and arm action, which determines the trajectory and speed of the ball.

➤ *Sampling Technique*

The purposive sample method was used to select the sample. Sabaragamuwa University of Sri Lanka has a large pool of premier level medium-fast bowlers. However, for this research, particularly interested in comparing the bowling techniques of the two groups. Top performers and underperformers.

➤ *Data Collection Methods*

Firstly, a pilot test utilizing high-speed cameras captured detailed video analysis of bowlers' delivery strides, revealing subtle movements crucial to accuracy. Secondly, a standardized cricket-specific bowling accuracy test provided objective measurements for comparison between participants. Finally, employed observations and interviews to delve into the bowlers' perspectives, experiences, and training routines, gathering qualitative insights beyond mere numbers. This comprehensive approach aimed to paint a holistic picture of the factors influencing bowling accuracy and potential avenues for improvement.

➤ *Video Capturing*

Two cameras were employed by the researcher for the video analysis. In this study it was important to examine the three components (arm action, hip rotation and foot placement) of the medium fast bowler's delivery stride, so this video frame should focus on each stage. And researcher used cameras to get clear videos of medium fast bowlers. The player's performance sagittal plane camera was placed on 5.56 meter away from objective, the camera was placed on 1.40-meter height. The front camera was placed 9.90 meter away and 1.40-meter height from the objective. The trajectory of the center of gravity was shown to be coordinated. Every camera was synchronized with a speed light (Godox tt650). Before filming, use a pole to calibrate the vertical axis in the sagittal plane.

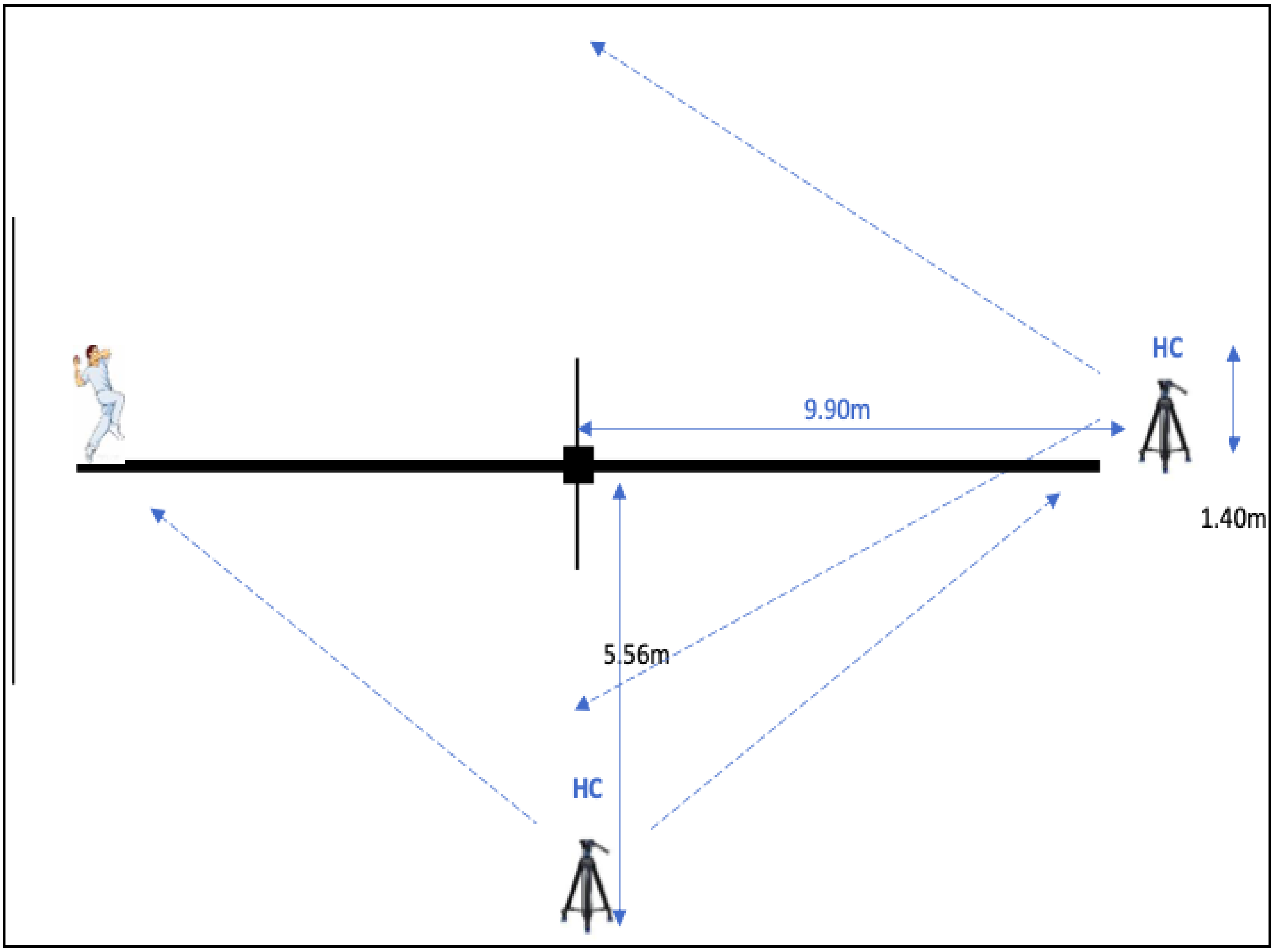

Fig 1 High Speed Camera (HC) Placement

Fig 2 Accuracy Test Ground Arrangement

Table 1 The Accuracy Test Scoring Rules and Scoring Sheet

Scoring Rules

Target	Points awarded
Hitting 4 point area	4 points
Hitting 3 point area	3 points
Hitting 2 point area	2 points
Hitting 1 point area	1 points
Beyond 1 point area	0 point

Scoring sheet

Name							
Age							
Level of play	District	School		University		State	
Preferred type of fast bowling	Side on			Front on			
Preferred hand	Left			Right			
No. of balls	Ball 1	Ball 2	Ball 3	Ball 4	Ball 5	Ball 6	Total Score
Over1							
Over2							
Over3							
Over4							

➢ *Data Analysis*

The entire data will be collected by cricket bowlers' delivery stride and biomechanical model analysis were provided by the researcher. SPSS software are going to be used in analyzing the validated data. The recorded data from the 2D motion video capturing done by using 50Hz high speed camera and analyzed by using Kinovea software (version 0.9.5).

➢ *Calculating Kinematic Variables*

Video analysis unveiled critical components such as hip rotation, foot positioning, and arm movement. Additionally, through the same video analysis using Kinovea, the velocity of fastballs was precisely measured. This comprehensive examination allowed for a deeper understanding of the mechanics involved in delivering fastballs.

➢ *Statistical Data Analysis*

Following the video analysis conducted with Kinovea, the extracted data was transferred into the R software in the form of an Excel file. This facilitates further examination and manipulation of the analyzed results within the R software. By leveraging the capabilities of R software, researchers can delve deeper into the data, perform statistical analyses, and derive meaningful insights.

III. RESULTS AND DISCUSSION

Table 2 Anthropometric Measurements of Medium Fast Bowlers

Segmental Lengths (cm)	Leg	Hand	Hip	Upper arm	Lower arm
Player A	94cm	58cm	80cm	27cm	25cm
Player B	101cm	76cm	84cm	34cm	29cm
Player C	96cm	66cm	82cm	30cm	25cm
Player D	90cm	50cm	88cm	26cm	24cm

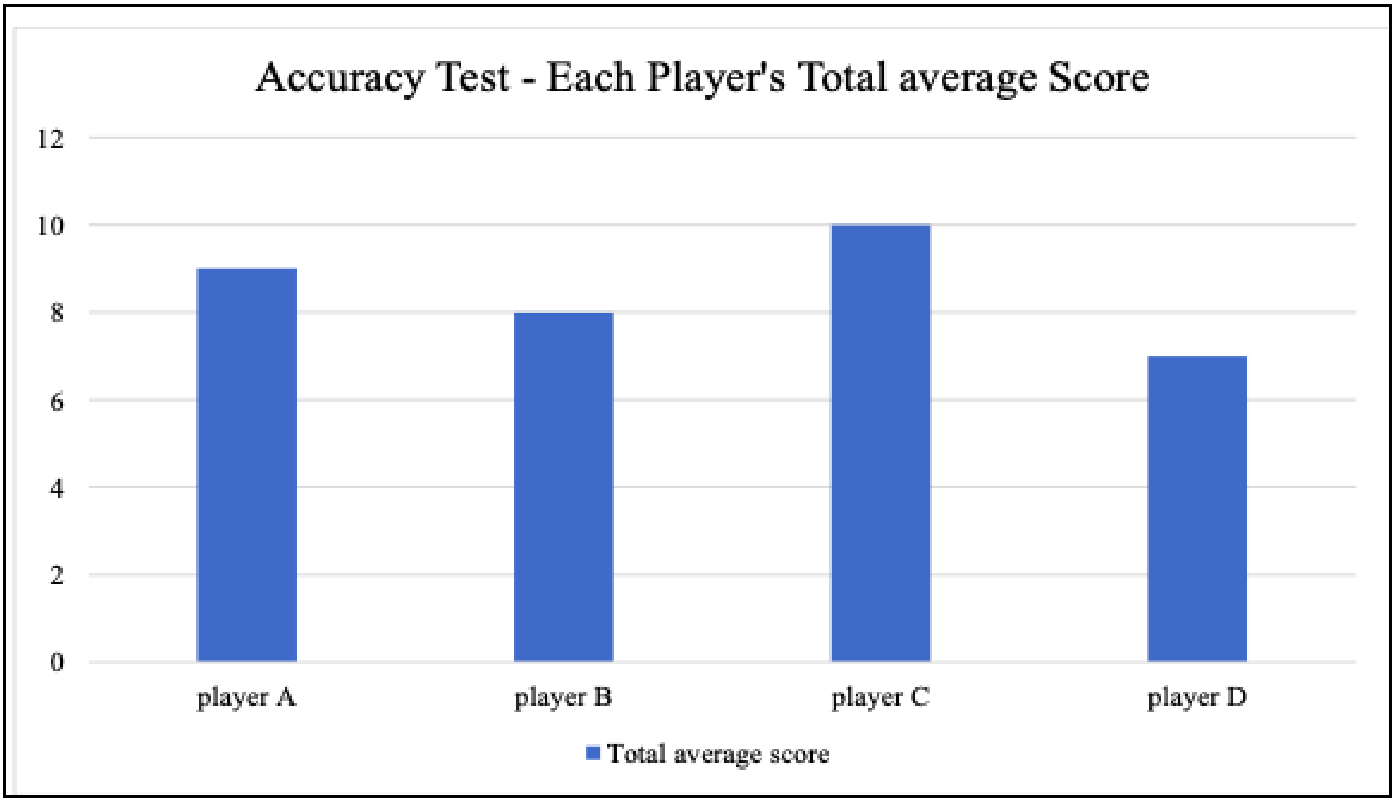

Fig 3 Chart of Each Player's Total Average Score

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

The field is first arranged to ascertain the accuracy of the players. After that each player was given 30 overs to measure their accuracy. The players threw the ball on the organized field and the score was recorded by the observer. After that their total score was predicted.

Table 3 Each Player's Total Speed Score

Samples	1st ball	2nd ball	3rd ball	4th ball	5th ball	6th ball	Average speed
Player A	92.38	101.55	98.38	100.08	98.38	104.36	99.19
Player B	111.45	112.53	114.3	112.64	119.48	117.66	114.68
Player C	110.95	109.29	106.56	96.48	106.04	107.96	106.21
Player D	109.29	115.95	113.68	107.06	115.45	109.8	111.87

Player A consistently recorded the lowest ball speeds, ranging from 92.58 km/h to 104.36 km/h, with an average speed of 99.19 km/h, suggesting limited pace generation during the delivery stride. Player B demonstrated higher and more stable performance, maintaining speeds between 111.45 km/h and 117.66 km/h, achieving an average of 114.98 km/h, which indicates efficient stride mechanics and arm action. Player C's performance fluctuated significantly, with a marked drop in the 4th and 5th deliveries (96.48 km/h and 106.04 km/h), yet the average remained relatively high at 106.21 km/h, pointing towards inconsistency in delivery execution. Player D recorded the highest overall speeds, consistently exceeding 107 km/h and reaching a peak of 119.23 km/h, with an impressive average of 111.87 km/h, reflecting superior biomechanical efficiency and stability in stride execution.

- *Kinematic Variables*

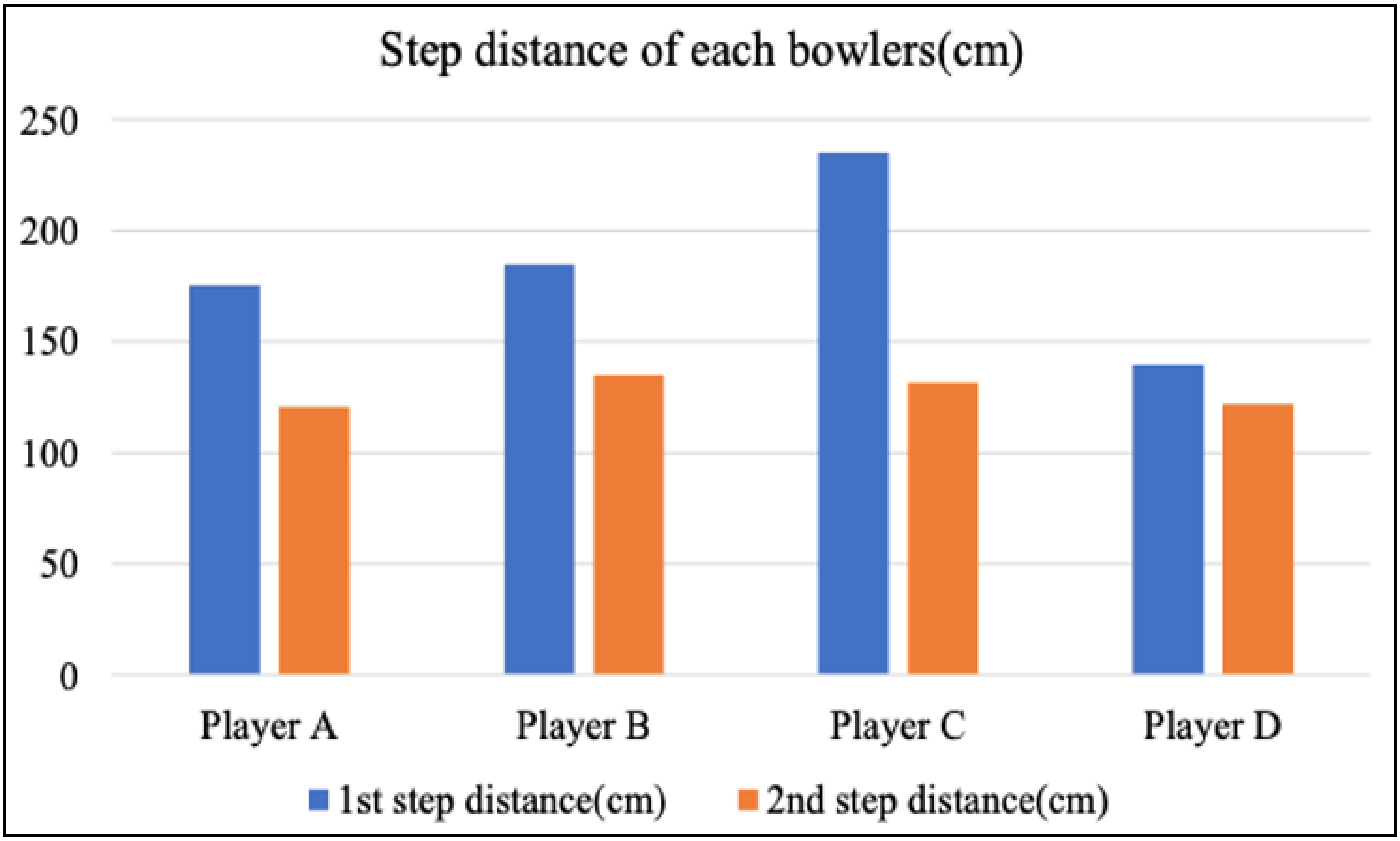

Fig 4 Chart of Step Distance of Each Bowler's (Cm)

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

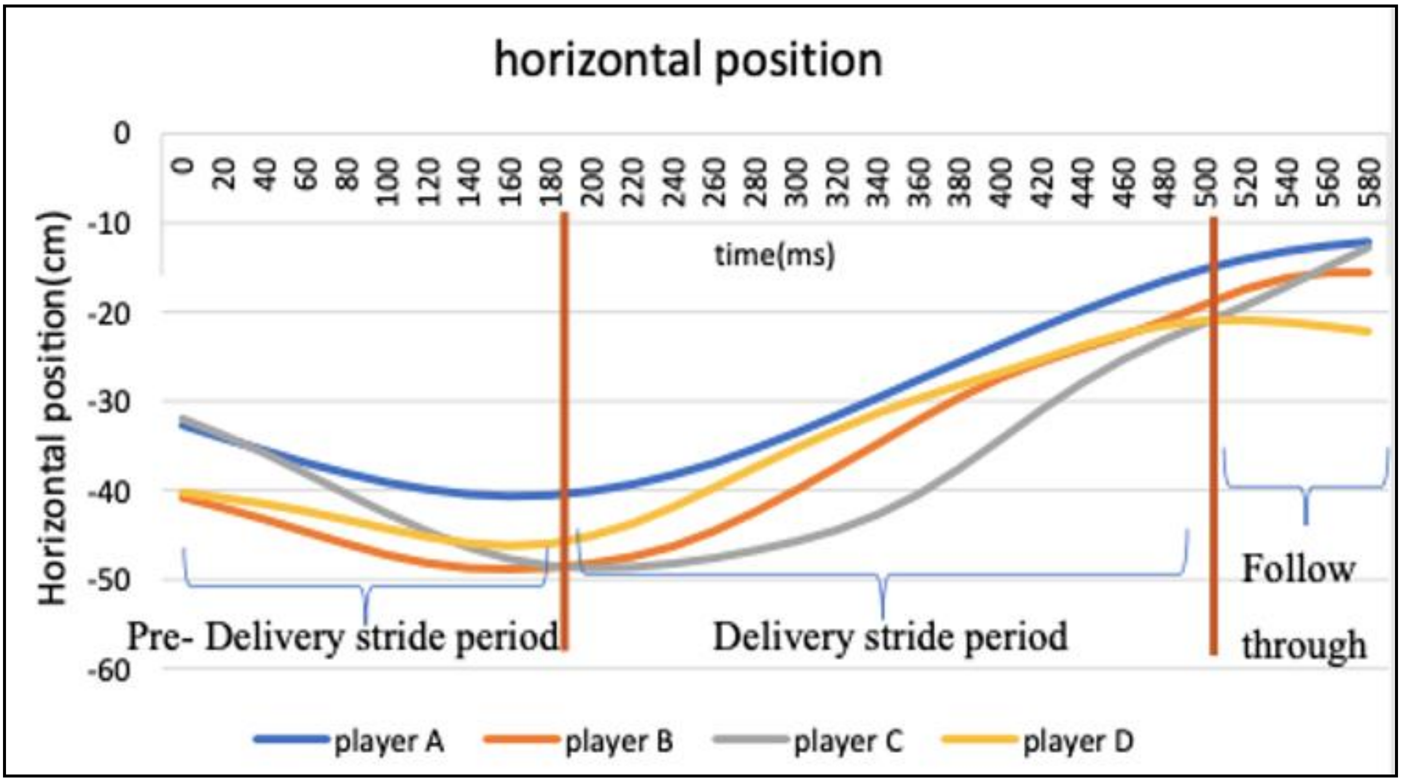

Fig 5 CG Graph of Overall Performance of the Horizontal Position of All Players

The graph presents the horizontal positioning of four players over a series of time intervals related to their bowling delivery stride. The pre-delivery stride of players concludes within a time frame of 160ms to 200ms, signaling the commencement of the delivery stride period. This phase persists for approximately 500ms, followed by a subsequent follow-through period lasting from 500ms to 580ms. The transition from pre-delivery stride to delivery stride occurs approximately -50cm from the players' position. Throughout the delivery stride period, horizontal positioning ranges from -40cm to - 50cm initially, decreasing to -22cm to -10cm as the stride progresses. The follow-through phase then ensues, maintaining the flow of the players' motion.

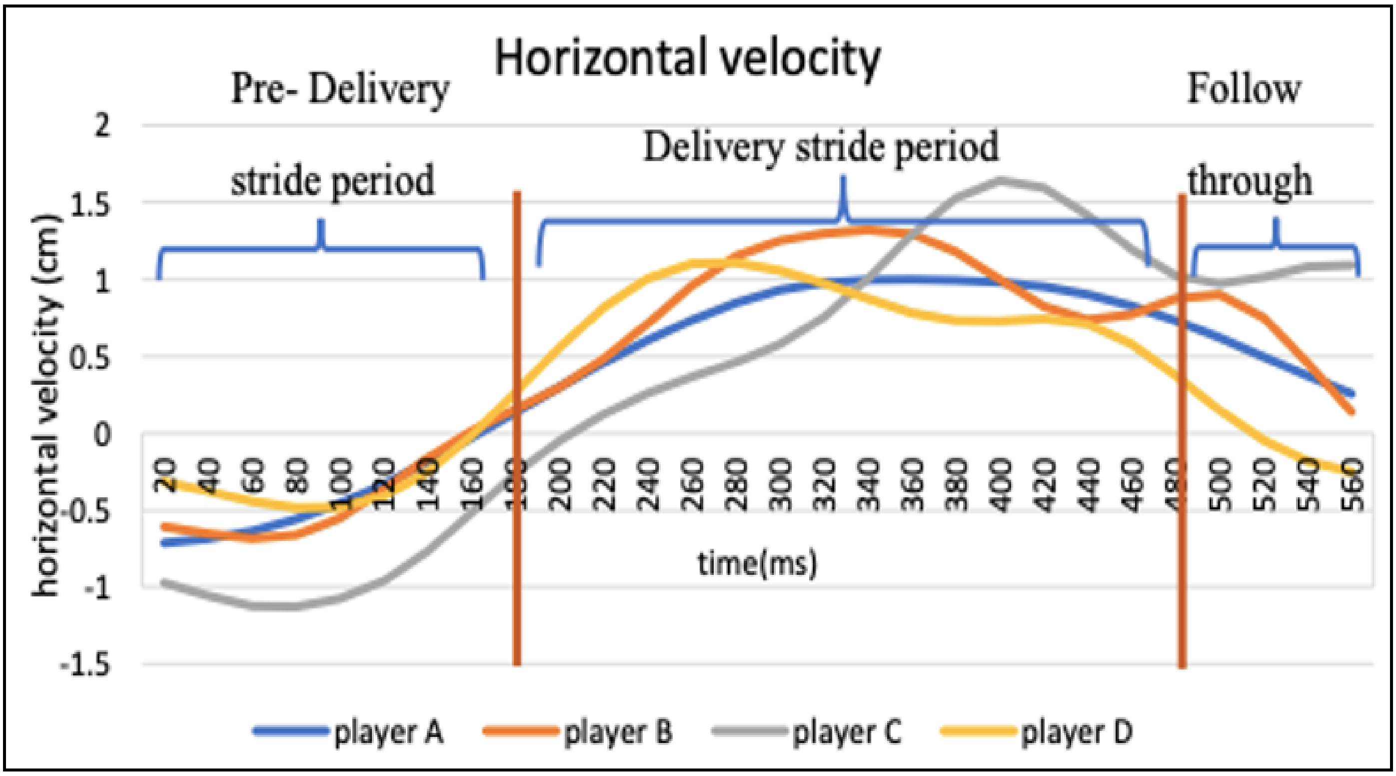

Fig 6 Overall Performance of the Horizontal Velocity of All Players

According to the graph, Each player exhibits a unique pattern of acceleration and deceleration, which may influence their ability to generate speed and control the direction of the ball. Coaches can leverage these insights to refine a player's approach and enhance their performance on the field.

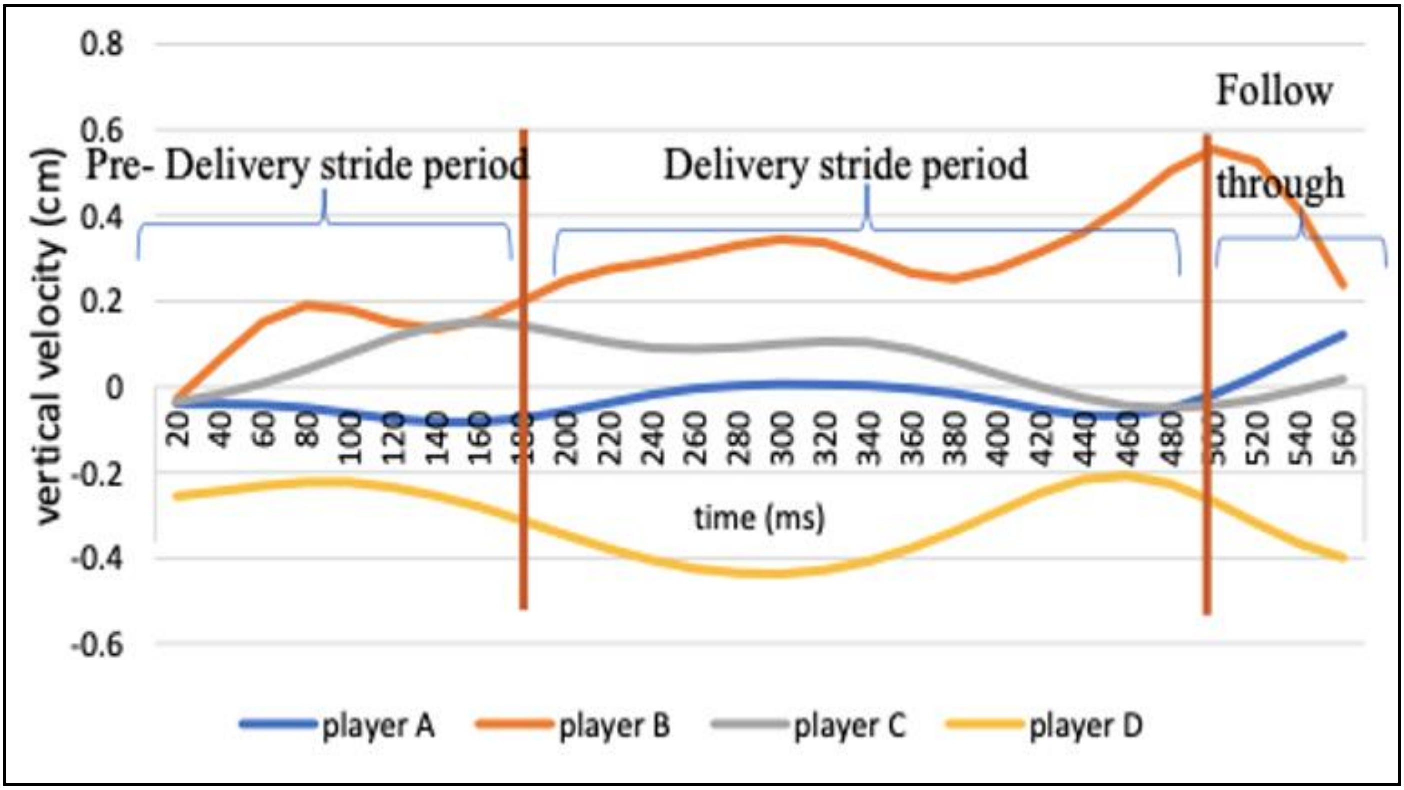

Fig 7 Overall Performance of the Vertical Velocity of All Players

In examining the "vertical velocity graph" depicting the change in vertical velocity of players A, B, C, and D throughout the phases of a delivery stride, we gain insights into the dynamics of their bowling actions. This graph provides a breakdown of each player's vertical velocity during the pre-delivery stride, the delivery stride, and the follow-through.

Table 4 Result of Linear Kinematics Correlations with 2nd Step

	Acceleration	Horizontal acceleration	Horizontal position	Horizontal velocity	Speed	Total distance	Vertical acceleration	Vertical position	Vertical velocity	2nd Step
Acceleration	1.00									
Horizontal acceleration	-0.55	1.00								
Horizontal position	-0.64	0.98	1.00							
Horizontal velocity	0.06	0.06	-0.11	1.00						
Speed	-0.44	-0.43	-0.38	0.27	1.00					
Total distance	-0.59	-0.29	-0.22	0.19	0.98	1.00				
Vertical acceleration	-0.68	0.95	0.99	-0.21	-0.35	-0.18	1.00			
Vertical position	-0.93	0.21	0.31	0.00	0.74	0.85	0.36	1.00		
Vertical velocity	-0.23	0.14	0.01	0.95	0.46	0.42	-0.07	0.30	1.00	
2nd Step	-0.07	-0.45	-0.51	0.74	0.81	0.72	-0.55	0.35	0.80	1.00

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

Analyzing linear Kinematics of the data, a profound understanding of the intricate relationship between stride and various key variables emerges. Notably, horizontal velocity (r = 0.74), speed (r = 0.81), total distance (r = 0.72), and vertical velocity (r = 0.80) exhibit compelling patterns that underscore their influence on the length of the stride during the bowling action. Conversely, the correlation between stride and horizontal position (r = -0.51), as well as vertical acceleration (r = -0.55), presents an intriguing contrast. With a r-value negative value, the data indicates a strong negative correlation between these variables and stride. This implies that as horizontal position and vertical acceleration decrease, the length of the stride tends to increase.

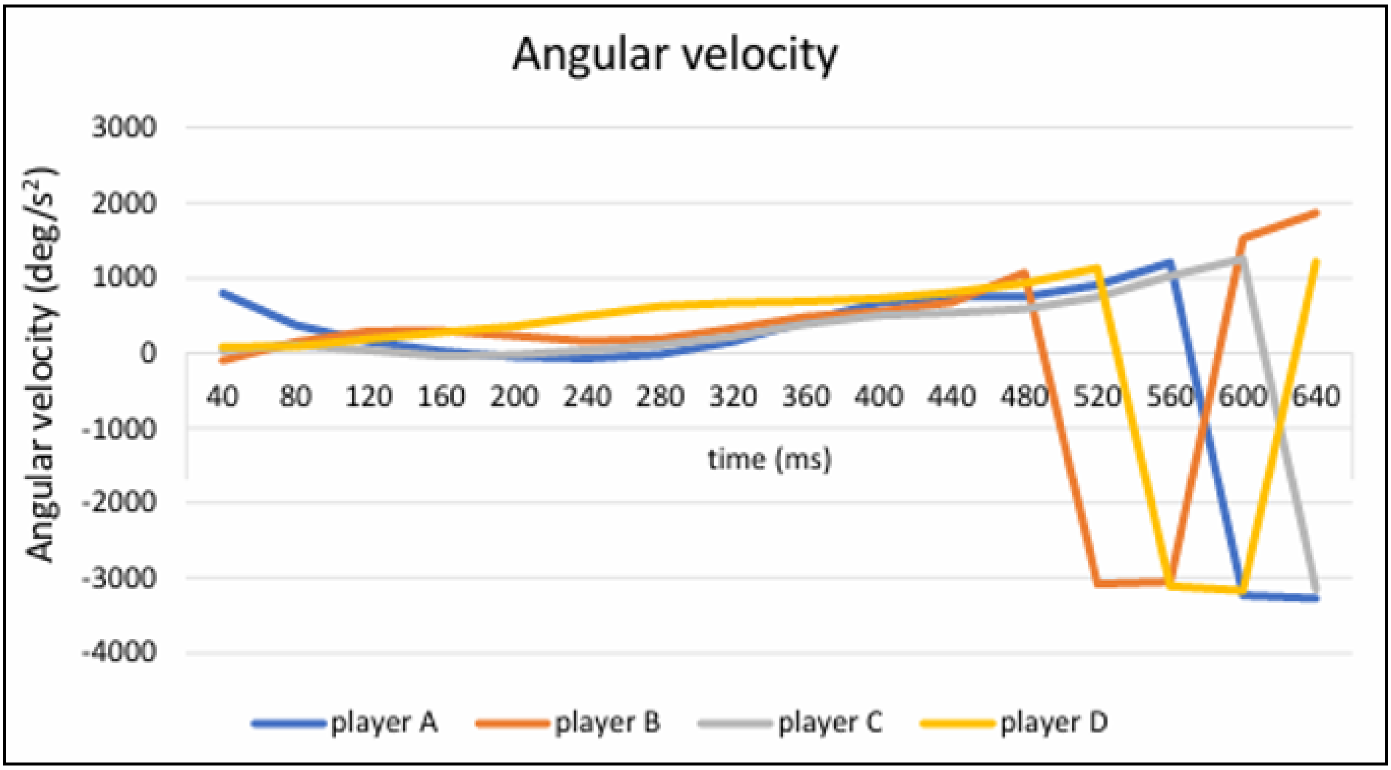

Fig 8 Overall Performance of the Angular Velocity of All Players

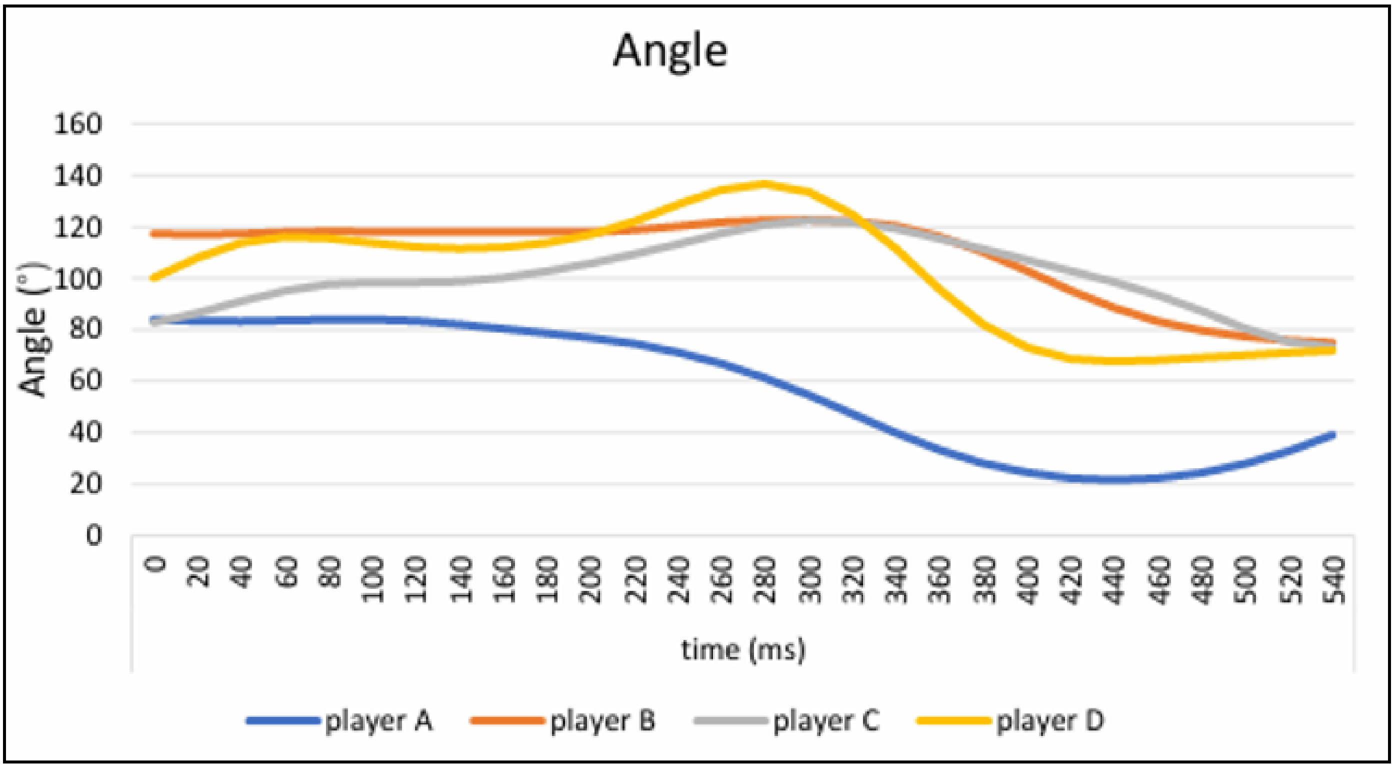

Fig 9 Lateral Pelvic Tilt Motion Graphs

The lateral pelvic tilt angle graph offers a detailed overview of how the pelvic tilt of each player evolves throughout their bowling delivery stride, measured in milliseconds (ms) for time and degrees (°) for the angle. Player A: - 65.573, Player B: - 105.595, Player C: - 97.191, Player D: - 102.262.

Table 5 Result of Angular Kinematics Correlation with 2nd Step

	Angular acceleration	*Angular velocity*	*2nd Step*
Angular acceleration	1		
Angular velocity	0.002051214	1	
2nd Step	0.629224939	-0.770779046	1

With a correlation coefficient of (r = 0.629) the data highlights a positive correlation between stride and angular acceleration. This suggests that as angular acceleration increases, so does the length of the stride taken by the bowler. Conversely, the correlation between stride and angular velocity presents a contrasting scenario. The data reveals a correlation coefficient of, accompanied by a negative (r = -0.77). This indicates a strong negative correlation between stride and angular velocity. In simpler terms, as angular velocity decreases, the length of the stride tends to increase.

Table 6 Result of Lateral Pelvic Tilt Motion Correlations with 2nd Step

	Angle	*Angular acceleration*	*Angular velocity*	*Total displacement*	*2nd Step*
Angle	1.00				
Angular acceleration	-0.54	1.00			
Angular velocity	-0.92	0.29	1.00		
Total displacement	0.53	-0.92	-0.19	1.00	
2nd Step	0.63	0.01	-0.47	0.27	1.00

Analyzing Lateral pelvic tilt motion, an intriguing picture begins to emerge regarding the relationship between stride, angle, and angular velocity. The angle, measured at (r = 0.63), showcases a strong positive correlation with stride. This suggests a significant association between the angle of approach and the length of the stride taken by the players. It implies that as the angle increases, so does the length of the stride, indicating a direct proportional relationship between the two variables. Conversely, the angular velocity presents a contrasting scenario. With a correlation coefficient of (r = - 0.47) and, the data reveals a negative correlation between stride and angular velocity. This implies that as the angular velocity decreases, the length of the stride tends to increase.

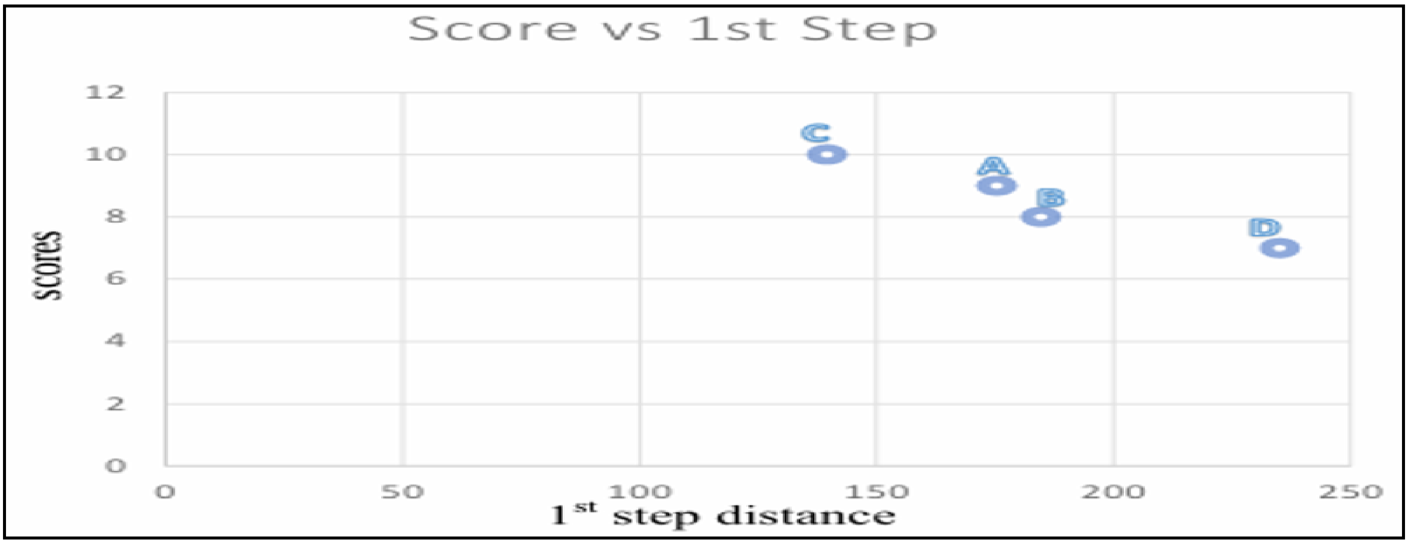

Fig 10 Accuracy Result of Score vs 1st Step for Each Player's

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25dec740

The graph's clear pattern emerges of the scores show a consistent decrease as the distance of the first step increases. Player A kicks off with a first step measuring 175.43 cm, earning a respectable score of 9. Moving on to Player B, their initial stride a slightly longer distance at 184.69 cm, resulting in a score of 8. Then, Player C notably shorter first step of 139.66 cm yet garners the highest score of 10. Finally, Player D takes a sizable leap with a first step stretching to 235.15 cm, and marked as a score of 7.

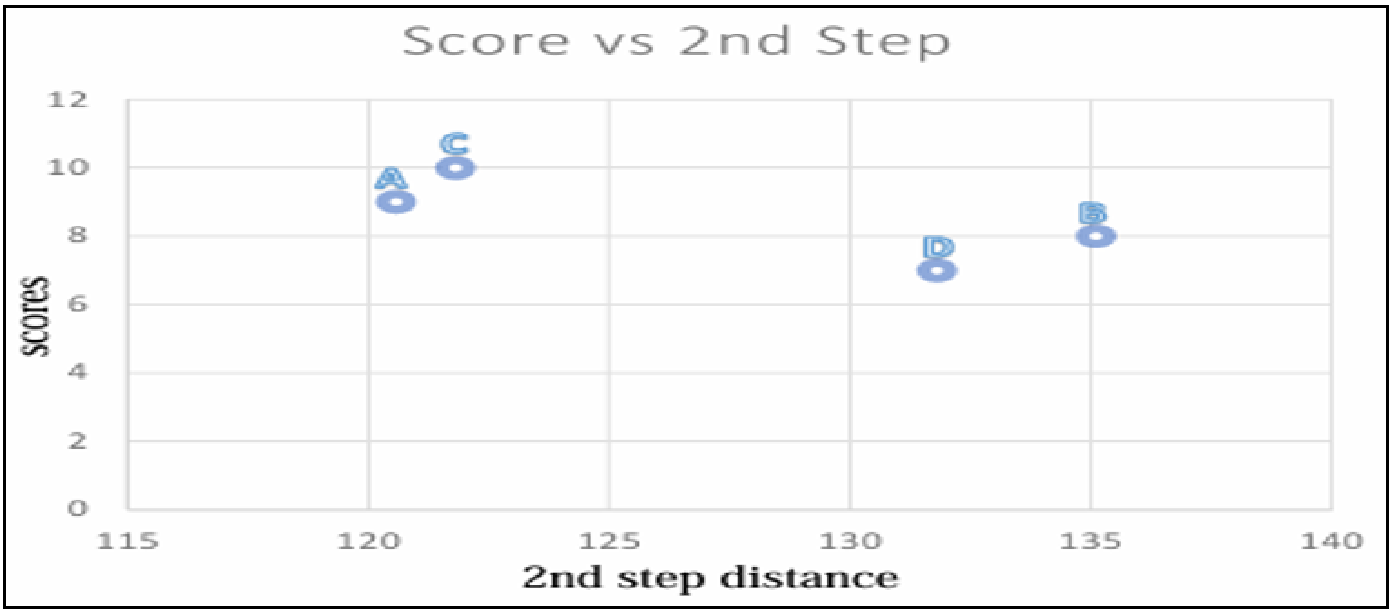

Fig 11 Accuracy Result of Score vs 2nd Step for Each Player's.

Player A takes their second step spanning 120.58 cm, maintaining their performance with a score of 9. Meanwhile, Player B extends their reach to 135.11 cm for the second step, leading to a slightly diminished score of 8. Player C, with a consistent approach, matches their first step with a second step distance of 121.81 cm, securing another perfect score of 10. Lastly, Player D ventures into the realm of excessive distance with a stride spanning 131.81 cm, resulting in a score of 7.

IV. CONCLUSION

In conclusion, refining the delivery stride is important for enhancing the performance of medium fast bowlers, particularly among premier level cricketers in Sri Lanka. The considerations outlined, such as the length, timing, foot placement, body positioning, and follow-through, offer a framework for coaches and players to optimize bowling effectiveness. Firstly, the length of the stride must strike a delicate balance between momentum generation and maintaining control. While longer strides can potentially increase speed by using momentum, excessively long strides may compromise balance and precision, resulting in accuracy issues.

Moreover, the timing of the stride within the bowling action is a predominant factor. A well timed stride facilitates a seamless transfer of energy, contributing to the fluidity and efficiency of the delivery. By emphasizing the synchronization of the stride with the overall bowling motion, coaches can help bowlers to control their body's momentum effectively. Additionally, attention to foot placement upon landing is crucial for establish the direction and trajectory of the ball. Proper alignment of the front foot enhances accuracy and consistency in bowling.

Furthermore, maintaining optimal body positioning throughout the delivery is essential for both speed and accuracy. A stable and balanced posture aids in generating power and control, allowing bowlers to optimize their performance. Coaches can work with bowlers to ensure they maintain a strong, upright position, promoting stability and efficiency in their bowling action.

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