Fast Bowling in Cricket: A Biomechanical Review of Performance, Technique, and Injury Mechanisms

H. M. S. S. Herath[1]; J. P. S. Jayaneththi[2]

[1,2]Department of Sport Sciences & Physical Education,
Sabaragamuwa University of Sri Lanka & P. O. Box 02, Belihuloya 70140, Sri Lanka

Publication Date: 2026/02/11

Abstract: The purpose of the study is to determine the kinematic and kinetic values of the fast-bowling technique in cricket that influences the performance and the risk of injury. Fast bowling is a high intense activity that significantly generates high speed of the ball and large mechanical forces particularly on lumbar spine. This systematic review reveals the various methods to prevail over-shoulder counter- rotation following back foot landing to lumbar injuries. This review included 16 authoritative journals that examined the biomechanics of cricket fast bowling. Elite and sub elite male and female fast bawlers were selected. The data related to run-up speed, back and front foot contact, trunk and shoulder motion, joint kinematics, and ground reaction forces were analyzed. Higher ball release speeds were positively corelated to the faster run-up speed, front leg bracing, trunk flexion, delayed arm action, and pelvis–shoulder separation. The Bowling techniques such as excessive rotation of shoulders, and lack of trunk control is increased the load on the lumbar spine. Female bowlers exhibit lower running speeds and greater reliance on trunk and pelvic rotation during their movements.In conclusion, performance of fast bowling and the risk of injury are coordinated whole-body mechanics. Control of technique and frequent screening are the two issues that coaches must concentrate on to enhance performance and minimize the risk of injuries.

Keywords: *Ground Reaction Forces, Kinematics, Kinetics, Lumbar Injuries, Trunk Flexion.*

How to Cite: H. M. S. S. Herath; J. P. S. Jayaneththi (2026) Fast Bowling in Cricket: A Biomechanical Review of Performance, Technique, and Injury Mechanisms. *International Journal of Innovative Science and Research Technology*, 11(1), 3419-3428. https://doi.org/10.38124/ijisrt/26jan1386

I. INTRODUCTION

Cricket fast bowling is a complex, high-intensity skill that combines speed, strength, and precise biomechanical coordination to generate ball velocity while placing substantial mechanical stress on the body. The main aim of a fast bowler is to send the ball with maximum speed, and accuracy and reproducibility. Increased speeds of the ball release decrease the reaction time a batter has, and it is more likely to cause the errors. At the highest tier, fast bowlers have achieved speeds of over 35 ms^{-1} and highest speeds have gotten close to or even above 40 ms^{-1} on a regular basis. Such speeds can only be attained with a perfect coordination of the whole body starting with run-ups and finishing with release of balls. It has been observed that the fast-bowling action is thus a complicated chain of motions which combine linear momentum produced during the approach with high-speed segmental rotations of the trunk and upper limb. Worthington et al. (2013) Biomechanically, fast bowling puts exceptional demands on musculoskeletal system of the body. The ground reaction forces that occur during contact on the front foot could be four to seven times body weight, and huge torsional loads occur on the trunk and lumbar spine. These forces play a critical role in performance and also put bowlers at great risk of overuse injury especially stress fractures of the pars interarticular is. Consequently, fast bowling has been the subject of continuous research and researchers have tried to tell us about the features of technique that enable an increase in the ball speed and reduce the mechanical load on exposed structures. Portus et al. (2004) Initial biomechanical research was done on the separation of single kinematic variables related to more rapid deliveries. Regular relationships have been found between the speed of the ball release, the run-up velocity, front knee position, trunk motion, and arm position on key delivery stride moments. More rapid bowers are expected to come into the crease with more horizontal energy, have a longer front-foot contact, and have larger values of upper-trunk flexion before release. These aspects could be able to help in providing a positive transfer of linear movement to the angular movement of the trunk and the upper limb. Nonetheless, much of this earlier research was based on simple correlation studies, considering variables separately and ignoring the fact that the process of bowling is interactive. Worthington et al. (2013) The most important progress was provided by Worthington, King, and Ronson who used multiple regression methods to determine the most

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

influential elements of elite fast bowling technique. Their results showed that four parameters could account about 74 percent of the change in the speed of ball release in the case of senior male bowlers. These parameters included: run-up speed, front knee angle at the point of ball release, upper trunk flexion between front-foot contact and ball release and shoulder angle during front-foot contact. The quicker run-up, braced front leg, increased forward flexion of the trunk, and a slower onset of arm circumduction typified the fastest bowers.

The model is supported by this pattern whereby the whole-body linear momentum is created during the run-up and thereupon it is transformed into the angular momentum about the front foot making the trunk a strong connection between the lower and upper parts of the body. Felton et al. (2019) There are also significant implications of these findings to injury risk. The methods that entail excessive counter-rotation of the shoulder or improperly managed trunk movement are linked to high-spinal loading. Mixed bowling movements, specifically, have been identified with more lumbar stress and stress fracture. The issue of coaches and practitioners is thus to encourage movement patterns in a way that optimize the transfer of energy and which do not compromise mechanical efficiency and spine stability. To gain this balance, it is important to understand the biomechanical determinants of performance. Portus et al. (2004)

Although the sport of professional women in cricket has expanded, most of the research on the topic of fast bowling has focused on male players. This unbalance has given rise to the general belief that the best technique between male and female is the same. But there is new information indicating that this assumption is not correct. The comparative studies of elite men and women fast bowlers have indicated evident variations in the run-up speed, segmental sequencing and how the momentum is created and relayed. The result of the female bowlers is that they tend to generate less whole-body linear momentum in the approach and also seem to depend more on rotational impetus of the pelvis and the trunk, having a more of an overarm throw pattern. Such differences can be based on the differences in strength, anthropometry, and neuromuscular ability but not merely on technical choice. Felton et al. (2019) Similar results have also been noted in other projectile sports. In standing throws, the difference in performance according to sex is mostly due to strength as well as body dimensions instead of technique. Conversely, in run-up events, like the javelin throw, the elite males and females exhibit different segmental strategies especially in the mechanisms of the rear leg and trunk. Fast bowling has significant mechanical resemblance to such actions, which implies that one technical model is not likely to suit every athlete. Felton et al. (2019) Considering all these points, it is evident that there is a need to integrate available biomechanical data on fast bowling performance.

Although individual studies have determined the key variables, there is still a lack in the integration of findings across populations, methods, and level of performance. Further, the relationship between technique, performance and the risk of injury is usually addressed in isolation instead of in a single system. To distinguish between the consistent determinants and context specific results, to pinpoint gaps in the current knowledge, the topic needs to be thoroughly reviewed to understand how the ball speed is created in the mechanical pathways. Stuelcken et al. (2010) This review is thus an attempt to critically review biomechanical literature studies of cricket fast bowling paying special attention to performance-based determinants of ball release speed. This summary review will combine both pieces of kinematic and kinetic data of elite and sub-elite bowlers (both male and female where applicable) by integrating both to determine the essential technical attributes that form the basis of efficient fast bowling. Through this it attempts to offer a clear evidence-based basis upon which coaching practice, athlete development and injury prevention can be based in contemporary cricket. Middleton et al. (2016)

II. METHODOLOGY

The review took a narrative approach to the synthesis of biomechanics studies concerning fast bowling in cricket, and technically the speed of the ball release and its technical contributing factors. The literature on sports biomechanics and cricket science titles were determined as the sources of peer-reviewed research. The studies that analyzed quantitative biomechanical measurements of fast or fast-medium bowlers were taken into consideration. The sampling was based on the articles about elite, professional, or high-performance male and female fast bowlers. To be included in the studies, they had to report the speed of ball release and the kinematic or kinetic variables related to the same. Portus et al. (2004) Worthington et al. (2013) Investigations that focused solely on coaching opinions or injury incidence without biomechanical analysis were excluded. This approach ensured methodological consistency across the reviewed literature. In the studies included, data was frequently collected in indoor cricket facilities.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

Fig 1. Experimental Set-Up in the Indoor Cricket Training Facility. Ranson et al. (2008)

These conditions enabled bowlers to make full run-ups on regular artificial pits. This arrangement minimized the effect of weather and variation of surfaces and gave bowlers the opportunity to bowl at peak intensity. Worthington et al. (2013) All the studies included utilized three-dimensional motion capture systems. The most reported technology was Vicon motion analysis systems. Normal operating frequencies of such systems were in the high frequency range of around 300 Hz. The rate of these samples enabled perfect capture of the high motions in the fast bowling. Ranson et al. (2008) Specific anatomical landmarks were marked with reflective marks. These were the pelvis, upper and lower trunk, upper limbs and the lower limbs. The positioning of the markers was according to the existing full-body biomechanics models employed in past studies of fast bowling. Ranson et al. (2008)

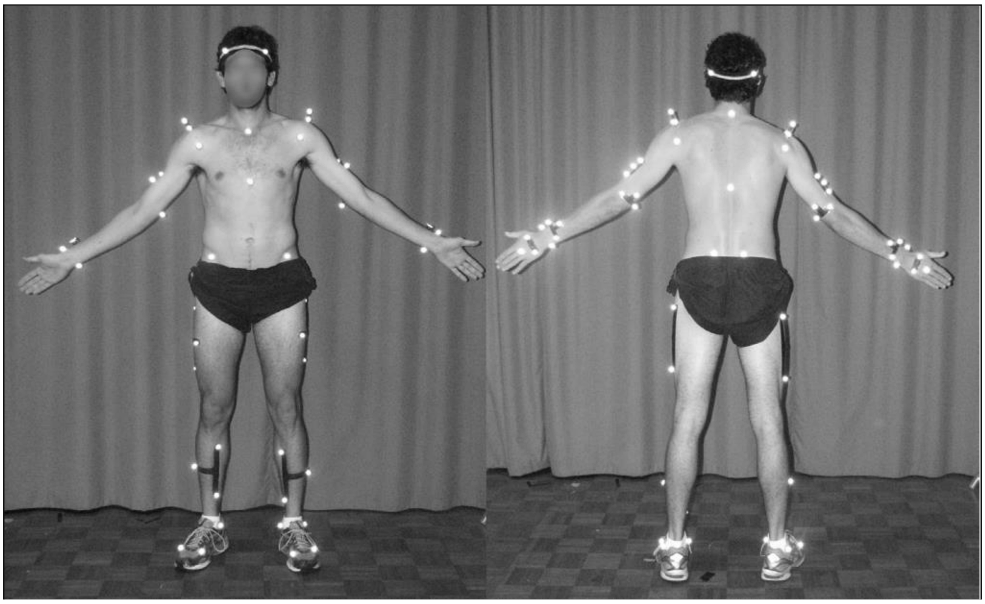

Fig 2. Participant Standing in an Anatomical T-Pose Showing Custom Marker Set. Middleton et al. (2016)

Most of the studies added an additional reflective patch or patch to the cricket ball. This allowed the correct determination of the release of the ball. It also enabled the calculation of the speed of releasing a ball with great accuracy, which is one of the main measurements of high-speed bowling. Middleton et al. (2016)

Bowlers were generally told to give the ball as hard as possible, though in good length. The majority of researches documented three to six births per study. Trials where the markers were lost or there were technical errors were not analyzed. The rest of the trials were subjected to biomechanical processing. Portus et al. (2004) The major phases of the fast bowling were found to vary across studies. These moments entailed back foot contact, front foot contact, front foot flat and ball release. Back foot contacts were considered as the first frame that the back foot came in touch with the ground during the delivery stride. Contact of the front foot was also identified in the same way. The release of the ball was assessed through the difference in the distance between the wrist and ball markers. Worthington et al. (2013)

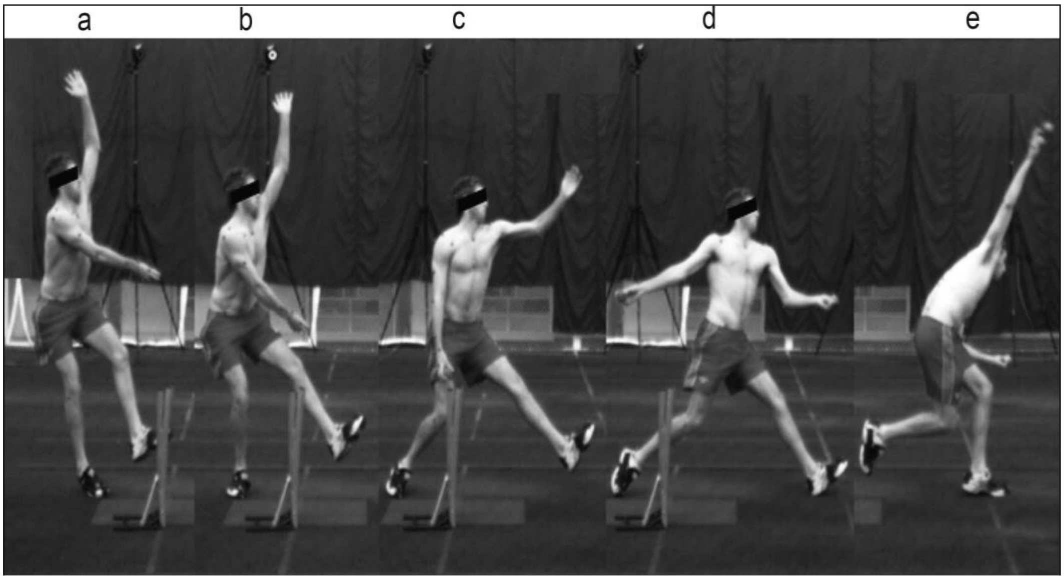

Fig 3. The Delivery Stride of Fast Bowling: (a) Back Foot Impact; (b) Back Foot Flat; (c) Minimum Shoulder Angle; (d) Front Foot Impact; (e) Ball Release. Ranson et al. (2008)

There were a wide number of biomechanical variables that were extracted in the studies that were reviewed. Such variables were run-up speed, Centre of mass velocity, length of delivery stride, and the height of ball release. Front and back knee angles were a common analysis in the lower limbs. There were also in-depth studies of hip and shoulder joints. The upper and lower trunk flexion and extension were trunk variables. The angle of pelvis and shoulder position was often reported. In order to evaluate trunk rotation and sequencing, pelvis-shoulder separation angle was examined. Felton et al. (2019) The kinematics between two bodies were determined by Cardan rotation series. These calculations were done in local and global coordinate systems. The international coordinate system was in most cases based on the cricket pitch. The angles of trunk orientation were commonly corrected using the pure calibration trials. This assisted in individual variation in posture and spinal orientation. Worthington et al. (2013) Before analysis, data on marker trajectory were filtered. Butterworth filters Low-pass Butterworth filters were most general.

This type of filtering minimized the noise of signals and retained actual movement patterns. The cut-off frequencies were chosen according to the biomechanical research findings of the past. Averages were taken to enhance reliability by taking the average of the trials of each bowler. This method minimized the effect of trial to variability. Research always indicated strong intra-class correlation coefficients. These values were normally higher than 0.90, which shows that there was a high repeatability of the measured variables. The studies had slight differences in the statistical analysis but the same principles. Relationships between the variables of individual techniques and the speed of ball release were often analyzed by the correlation analysis. The groups that were compared by independent sample t-tests and analysis of variance included faster versus slower bowlers or male versus female bowlers. The analysis of multiple linear regression was actively used to determine the most significant biomechanical predictors of the speed of ball release. Felton et al. (2019) Overall, the methodological approaches across the reviewed studies were consistent and robust. This consistency supports meaningful synthesis of findings and strengthens the biomechanical evidence base related to fast bowling performance in cricket.

III. RESULTS

The majority of the studies demonstrated an optimistic relationship between the run-up speed and the ball release speed. Quick bowlers had always exhibited an increase in approach velocities in the latter stages of the run-up. This enhanced horizontal momentum which added more energy in the kinetic chain during delivery stride. P. Worthington et al. (n.d.) Felton et al. (2019) P. J. Worthington et al. (2013) Kinematics of the lower limbs too were a significant factor in the performance of fast bowling. The front knee was found to be extended longer in fast bowers than in slow bowers. A straighter front knee was related to better vertical ground reaction forces and better energy transfer to the trunk and upper limb. A number of studies found out that the front knee extension angle on release of the ball was significantly correlated with the speed of release of the ball and that effective bracing of the front leg in the delivery stride is

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

important. Ferdinands (2011) Trunk kinematics were always found to play the important role of ball release speed. Quicker bowlers were found to have higher upper trunk flexion and rotation at the later stages of the delivery action. The higher release speeds linked to increased trunk flexion during the release of the ball indicated a better transfer of lower body momentum to upper body. Savage & Portus (n.d.)

Table 1 Range, Mean and Standard Deviation of the 11 Technique Parameters.

Technique Variable	Range	Mean ± SD
Run-up speed (m-s^{-1})	4.77–6.76	5.79 ± 0.58
Knee angle at FFC (°)	148.3–172.7	164.1 ± 6.1
Knee angle at BR (°)	120.3–186.2	167.3 ± 18.8
Knee flexion from FFF till BR (°)	0.0–44.8	17.5 ± 11.2
Knee extension from FFF till BR (°)	0.3–26.3	11.9 ± 7.4
Shoulder girdle forward rotation (°)	80.6–143.4	115.5 ± 18.2
Upper trunk flexion from FFC till BR (°)	11.2–50.6	31.0 ± 8.3
Shoulder angle at FFC (°)	288.0–365.0	331.2 ± 22.1
Shoulder angle at BR (°)	186.9–257.6	219.4 ± 15.3
Minimum pelvis–shoulder separation (°)	−63.3 to −27.5	−39.6 ± 9.6
Time of minimum pelvis–shoulder separation (s)	−0.020 to 0.057	0.031 ± 0.019

Abbreviations: **FFC**: Front Foot Contact; **FFF**: Front Foot Flat; **BR**: Ball Release

The analyzed articles all tended to reveal that there is a close relationship between the performance of fast bowling and the combination of the speed of the run-up, lower-limb, trunk, and upper limb kinematics. Worthington et al. (n.d.) In all of the studies, the key outcome of performance was the ball release speed, and numerous biomechanical variables were supposed to be among the crucial factors to achieve higher release speeds. Portus (2001) The majority of the studies demonstrated an optimistic relationship between the run-up speed and the ball release speed.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

Table 2. Group Means (±SD) and Comparison Between Selected Kinematic Variables. Pearson's Product–Moment Correlation Coefficients (r) are Reported Between Selected Kinematic Variables and Ball Release Speed. BFI: Back Foot Impact; BR: Ball Release; FFI: Front Foot Impact; Max: Maximum.

Kinematic variables	Amateur		High performance		p-value	Effect size
	Mean	(SD)	Mean (SD)	Correlaton)		
Ball release speed (m/s)	27.7 (1.5)	—	31.1 (1.5)	—	<0.001*	2.27
Stride length (mm)	1280.3 (186.9)	0.279	1384.4(152.0)	−0.006	0.110	0.61*
Stride length (% of height)	69.1 (8.8)	0.198	73.5 (7.4)	−0.121	0.160	0.54
Centre of mass speed (@ BFI) (m/s)	4.5 (0.6)	0.234	5.1 (0.6)	0.556*	0.024*	1.00
Centre of mass speed (@ BR) (m/s)	2.3 (0.6)	0.019	2.6 (0.4)	0.407	0.056	0.58
Back knee flexion angle (@ BFI) (°)	41.7 (10.7)	−0.174	46.8 (11.5)	−0.093	0.226	0.46
Max back knee flexion (BFI to FFI)	68.4 (7.5)	0.346	70.3 (10.4)	−0.029	0.497	0.21
Back knee flexion range (Max—BFI (°)	26.7 (11.2)	0.399	23.5 (13.6)	0.056	0.497	0.26
Front knee flexion angle @ FFI) (°)	16.2 (6.2)	−0.028	16.4 (7.0)	−0.122	0.946	0.03
Max front knee flexion (FFI to BR) (°)	45.1 (13.0)	−0.535*	35.6 (13.4)	0.098	0.063	0.72
Front knee flexion angle (@ BR) (°)	42.1 (19.1)	−0.606*	26.4 (22.3)	0.154	0.053	0.76
Front knee flexion angle (@ BR) (°)	42.1 (19.1)	−0.606*	26.4 (22.3)	0.154	0.053	0.76

Abbreviations: BFI: Back foot impact; ER1; Br: Front foot impact; FFI: Front foot impact; Max: Maxtimum.

*Significant difference/correlation ($p < 0.05$).

Quick bowlers had always exhibited an increase in approach velocities in the latter stages of the run-up. This enhanced horizontal momentum which added more energy in the kinetic chain during delivery stride. Kinematics of the lower limbs too were a significant factor in the performance of fast bowling. Stuelcken et al. (2010) The front knee was found to be extended longer in fast bowers than in slow bowers. A straighter front knee was related to better vertical ground reaction forces and better energy transfer to the trunk and upper limb.

A number of studies found out that the front knee extension angle on release of the ball was significantly correlated with the speed of release of the ball and that effective bracing of the front leg in the delivery stride is important. P. J. Worthington et al. (2013) Trunk kinematics were always found to play the important role of ball release speed. Quicker bowlers were found to have higher upper trunk flexion and rotation at the later stages of the delivery action. The higher release speeds linked to increased trunk flexion during the release of the ball indicated a better transfer of lower body momentum to upper body. Felton et al. (2019) The angle of pelvis and shoulder orientation were widely studied in the reviewed studies.

The speed of bowlers tended to have a bigger separation between pelvis and shoulder during the delivery stride. This isolation enabled them to have higher velocity of the trunk rotation before releasing the ball. P. J. Worthington et al. (2013) A number of publications reported moderate to high associations among the angle of pelvis shoulder separation and the speed of ball release, which justifies the presence of stretch shortening in the trunk muscles. There were also clear correlations between speed of release of the ball and upper-limb kinematics. Ferdinands et al. (2014) The rapid bowers exhibited a higher shoulder external rotation before discharging the ball, and then experienced a high speed of internal rotation during the acceleration period. This pattern of movement assisted in the generation of greater angular velocity of the shoulder joint and the greater release velocities. The increase in elbow extension was also more pronounced in the faster bowlers with excessive elbow extension not always being correlated with improved performance. A number of studies made a direct comparison between faster and slower bowlers. Ferdinands (n.d.)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

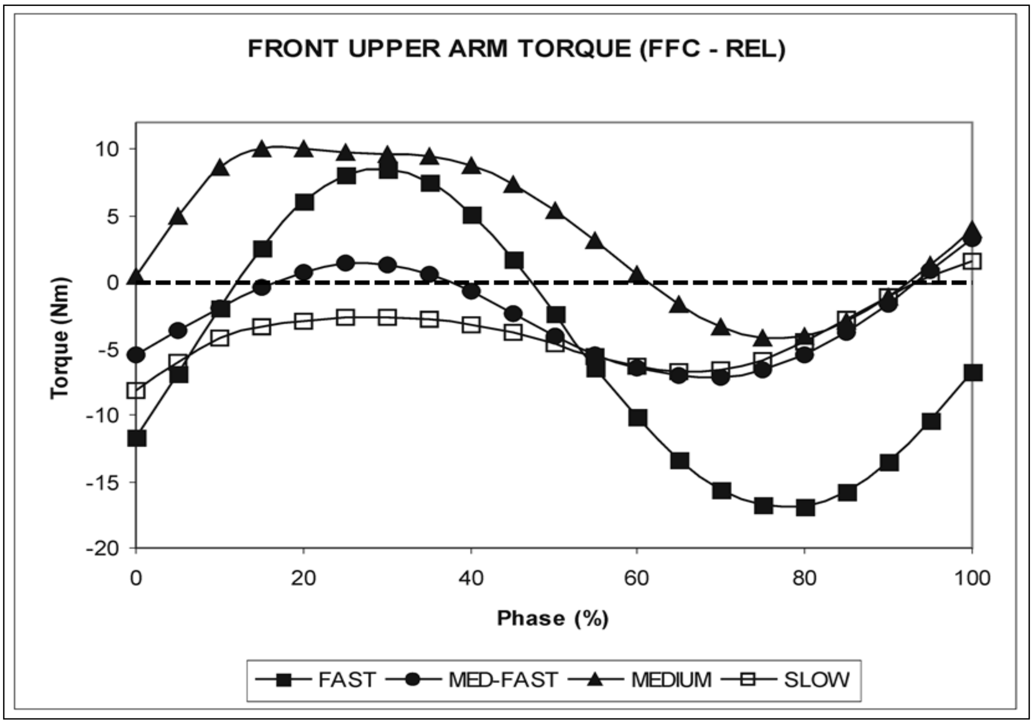

Fig 4: Ensemble Averages of Front Arm Upper Arm Torques the Vertical Abduction/Adduction Plane Relative to the Motion of the Thorax. Ferdinands (n.d.)

Positive is defined for abduction, the area of the graph above the dashed line. VR: 0.63 (fast), 1.00 (med-fast), 0.88 (medium), 1.00 (slow). More rapid bowlers were always better coordinated in lower-limb/trunk/upper-limb movements. The less effective bracing of the front leg and less trunk flexion at the release of the ball was exhibited by slower bowlers. These results indicate that the quality of technique and not the isolated joint actions is a significant contributor to high performance in fast bowling. The analyses of several studies through multiple regressions found combinations of variables as the most powerful predictors of the speed of ball release. Such variables were usually run-up speed, front knee angle, trunk flexion, pelvis-shoulder separation and shoulder rotation variables. Ferdinands et al. (2014) There was no single variable that could explain performance on its own, which supports the significance of whole-body coordination. Altogether, the findings of the studies reviewed reflected stable biomechanical patterns that were connected with increased speed of ball release. The use of the run-up, strong front leg actions, coordinated trunk actions, and efficient upper-limb actions were consistently discovered as the performance factors in the fast bowling.

IV. DISCUSSION

This review was aimed at reviewing biomechanical variables in relation to fast bowling performance; and more specifically, ball release speed. The critiqued articles all showed that the performance of fast bowling is affected by whole-body movement and not joint action. In the literature, the run-up speed, lower-limb mechanics, trunk kinematics, and upper-limb motion were found to be some of the most important factors in increasing the ball release speeds.M. Portus (2001) One of the key attributes to the performance of fast bowling in the majority of studies was run-up speed. Rapid bowlers had always recorded higher speeds in approach than the slow bowers. The higher the run-up speed the higher the momentum into the delivery stride and thus contributes to the more effective transfer of the energy to the kinetic chain. Ferdinands (2011)

The reviewed studies, however, also suggested that performance is not determined by run-up speed alone. High run-up speed bowlers who were poorly-technique could not always get higher ball release speeds. This shows the significance of the efficiency of technique in transforming approach speed to ball velocity.M. Portus (2001)The role of lower-limb mechanics especially the front leg action was always mentioned to be highly important in the performance of fast bowling. Increased front knee extension at the release of the ball was found in faster bowlers which made it possible to break the advance momentum of the body more effectively. M. R. Portus et al. (2004) It is an activity of the front leg brace that helps the trunk to move upwards and to rotate. The evidence is in line with the idea that a stable front leg offers mechanical support upon which energy flow between the lower and upper body is transferred during ball release. Stuelcken et al. (2010)

Trunk kinematics was determined as one of the most powerful contributors to the ball release speed. More rapid bowlers were always shown to have higher upper trunk flexion and successful trunk rotation in the proximity of the ball launch. These movements enable effective transmission of the lower limb generated energy to the bowling arm. Ferdinands (n.d.) The trunk motion excess or untimely movements was not linked to better performance. Rather it was the timing and regulated movement of the trunk that

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

seemed to be of significance than the size of the movement. Here the importance of coordination and sequencing in fast bowling technique can be noticed. Pelvis and shoulder separation was also commonly cited as one of the major variables that affected the performance of fast bowling. The bowers with higher speed had more separation between the shoulders and the pelvis when in the delivery stride. The resultant separation of the trunk enabled a greater velocity of rotation of the trunk via a stretch shortening mechanism of the trunk muscles. Ranson et al. (2008)

The results indicate that performance is not influenced by excessive rotation, but effective separation. These findings concur with the earlier biomechanical theories of proximal-to-distal sequencing of throwing and striking actions. M. R. Portus et al. (2004) Kinematics of the upper limb were also significant to measure the speed of ball release. The quicker bowlers showed more shoulder external rotation before the ball was released and high shoulder internal rotation speed during the acceleration stage. Burden & Bartlett (n.d.) These movements are direct contributors of ball velocity. Nevertheless, other studies reported that upper-limb variables performed best when assisted by powerful lower-limb and trunk mechanics. This supports the idea that the speed of fast bowling is coordinated by using the whole body and not the speed of the arm. Middleton et al. (2016) The faster bowlers and slower bowlers' comparisons also gave more insight on the difference in performance. There was always an improvement in body segment coordination in faster bowlers. Reduced front knee extension, reduced trunk flexion and lower effectiveness in pelvis-shoulder separation were performance characteristics seen in slower bowlers.

V. CONCLUSION

This review looked at the biomechanical variables related to the performance of fast bowling and more importantly the speed of the ball release. The results have clearly indicated that the movement or joint action does not dictate the performance of fast bowling. Rather, it is the well-coordinated movement of the entire body in the process of bowling. Bowlers with greater ball release speeds had consistently shown enhanced combination of run-up speed, lower-limb action, trunk action and upper-limb action. It was found that run-up speed is a significant factor in the performance of fast bowling.

Swift bowlers tended to employ a higher approach velocity that aided in creating a higher momentum prior to the delivery stride. This impetus formed the basis of the bowling movement. Nevertheless, the speed of run-up was not enough to achieve greater ball release velocities. Bowlers lacking the ability to control their approach and transfer momentum in the delivery stride did not always get the best results. This also displays the significance of having control and efficient run up mechanics instead of over speed. The mechanisms of lower limbs especially front leg action were pivotal in the performance of fast bowling. The longer and more stable front knee when releasing the ball enabled bowlers to successfully slow down acceleration. This is the braking effect that assisted in the raising and rotation of the trunk.

This powerful front leg also provided a firm platform on which the lower body energy can be transferred to the upper body. Stable bowlers that exhibited small front leg stability demonstrated lesser trunk motions and lesser ball release velocities. Trunk mechanics were also consistently discovered to be major factors of the speed at which the ball was released. Bowlers with good timing of trunk flexion and rotation towards ball release achieved more performance results. Efficient trunk movement was a means of ensuring that the energy produced by the lower limbs was able to be efficiently passed to the bowling arm. Synchronous or immoderate trunk movement was not helpful to increase performance and could decrease technical efficiency.

These results indicate that timing and coordination of movement is important not big ranges of movement. The other significant variable that affected the performance of fast bowling was pelvis and shoulder separation. The bowlers that exhibited a higher distance between the pelvis and shoulders during the delivery stride could produce higher velocities of trunk rotation. This isolation improved the input of the trunk into the speed of ball release. Proper sequencing and control were however needed to achieve effective separation. Too much identified uncoordinated rotation was not related with better performance. Mechanics of the upper limbs had a direct impact on the speed of ball release, but were highly modified by lower body and trunk motions. The best use of efficient shoulder and elbow movements was found with a stable lower-limb mechanics and a controlled trunk movement. This confirms the idea that the speed of fast bowling is based on the coordination of the whole body and not the speed of the arm.

Altogether, the results of the current review show that the performance of fast bowling is multifactorial and technically complicated. The coaches and practitioners ought to concentrate on creating coordinated movements throughout the whole bowling action. It should be trained with special attention to the controlled run-up speed, high front leg stability, effective trunk sequencing, and efficient arm action. Such a method can assist bowlers to gain better speed in ball release in spite of preserving technical efficiency and decreasing unwarranted mechanical loads.

VI. RECOMMENDATIONS

According to the results of this review, some effective recommendations may be given to coaches, athletes, and sports science practitioners that are interested in the development of fast bowling. These suggestions are aimed at acceleration of the speed of ball release by means of the increased technique, training design, and performance monitoring. More attention should be paid by coaches to training run-up mechanisms which are controlled and efficient. The run-up speed should be influenced in such a way that the bowlers are able to manage it with consistency. High approach speed without controlling could decrease the performance and technique efficiency. The drills during training should be aimed at keeping the rhythm and balance during the last stage of the run-up.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

They can be assisted with bowling by taking video recordings that help them determine how to fix discrepancies with approach speed. The fast-bowling training should focus on lower-limb strength and stability. Special care must be taken over front leg strength and control as the delivery stride takes place. Exercises that help to strengthen the front leg, including squats, lunges, and single-leg stability exercises can enhance front leg bracing. Plyometric exercises can also be applied to increase the lower-limb power and stiffness. To make the maximum out of such exercises, coaches ought to make sure that they are practiced in the right technique. Conditioning programs ought to focus on trunk strength and coordination. Core training must not be focused on excessive range of motion, but on strength and control. Rotational stability and rotational control exercises can assist in the improvement of trunk sequencing during the bowling movement. Medicine balls throws and controlled rotational exercises can be useful when it comes to functional trunk strength development. The trunk movements should be properly coordinated by the coaches with the lower-limb movements. Technical drills that focus on sequencing should be used to develop pelvis and shoulder coordination. To obtain an effective separation of the pelvis- shoulders without excessive rotation, the bowlers need to be trained on this issue.

Timing-based and rhythm-based exercises can be useful in enhancing this element of technique. Coaches must not promote the excessive stress on the spine or shoulders. Movement patterns of the upper limbs should be formulated in a parallel fashion with the entire body. arm speed is not to be trained separately. Exercises on the shoulder strength and mobility should be incorporated to promote good bowling skills. Such exercises are however advised to supplement lower-limb and trunk exercises and not to substitute them. The stress should be put on efficient and smooth arm action.

Biomechanical evaluation should be performed regularly to keep track of technique and performance. Technical strengths and weaknesses can be identified with the help of motion analysis, video analysis, or simple field-based tests. Individualized training interventions should be guided using these assessments. Changes with time should be monitored by coaches and practitioners instead of being based on individual evaluations.

The loads of training are to be handled with care in order to minimize the risk of being injured. Sudden changes in bowling volume or intensity should be avoided by bowlers. SCT programs are to be developed slowly. It should have a sufficient rest time incorporated in training programs. Overuse injury can be avoided by checking the fatigue levels. Lastly, the performance of fast bowling among various age groups and skill levels should persist in the future research. It would be worthwhile to have studies devoted to the development of long-term techniques and the increase of performance. A study of the relationship between performance and injury risk can also contribute to the provision of safer and more effective coaching practice.

REFERENCES

[1]. Ferdinands, R. E. D. (n.d.). MECHANICS OF THE FRONT ARM TECHNIQUE IN CRICKET FAST BOWLING.

[2]. Burden, A. M., & Bartlett. (n.d.). A KINEMATIC INVESTIGATION OF ELITE FAST AND FAST-MEDIUM CRICKET BOWLERS Aloager Stoke-on-Trent ST7 2HL ENGLAND.

[3]. Portus, M. (2001). RELATIONSHIPS BETWEEN CRICKET FAST BOWLING TECHNIQUE, TRUNK INJURIES, AND BALL RELEASE SPEED.

[4]. Worthington, P., King, M., & Ranson, C. (n.d.). THE EFFECT OF SELECTED KINEMATICS ON BALL SPEED AND GROUND REACTION FORCES IN FAST BOWLING.

[5]. Ranson, C. A., Burnett, A. F., King, M., Patel, N., & O'Sullivan, P. B. (2008). The relationship between bowling action classification and three-dimensional lower trunk motion in fast bowlers in cricket. Journal of Sports Sciences, 26(3), 267–276. https://doi.org/10.1080/02640410701501671

[6]. Portus, M. R., Portus, M. R., Mason, B. R., Elliott, B. C., Pfitzner, M. C., & Done, R. P. (2004). Cricket: Technique factors related to ball release speed and trunk injuries in high performance Cricket fast bowlers. Sports Biomechanics, 3(2), 263–284. https://doi.org/10.1080/14763140408522845

[7]. Stuelcken, M. C., Ferdinands, R. E. D., & Sinclair, P. J. (2010). Three-dimensional trunk kinematics and low back pain in elite female fast bowlers. Journal of Applied Biomechanics, 26(1), 52–61. https://doi.org/10.1123/jab.26.1.52

[8]. Ferdinands, R. E. D., Sinclair, P. J., Stuelcken, M. C., & Greene, A. (2014). Rear leg kinematics and kinetics in cricket fast bowling. Sports Technology, 7(1–2), 52–61. https://doi.org/10.1080/19346182.2014.893352

[9]. Ferdinands, R. E. D. (2011). Analysis of segmental kinetic energy in cricket bowling. Procedia Engineering, 13, 246–251. https://doi.org/10.1016/j.proeng.2011.05.080

[10]. BiomandPhysicalBowling1986. (n.d.).

[11]. Middleton, K. J., Mills, P. M., Elliott, B. C., & Alderson, J. A. (2016). The association between lower limb biomechanics and ball release speed in cricket fast bowlers: A comparison of high-performance and amateur competitors. Sports Biomechanics, 15(3), 357–369. https://doi.org/10.1080/14763141.2016.1163413

[12]. Run faster, bowl faster: In-match analysis of elite female cricket pace bowlers. (2023). The Journal of Sport and Exercise Science, 7(1). https://doi.org/10.36905/jses.2023.01.03

[13]. Savage, T. N., & Portus, M. R. (n.d.). A KINEMATIC ANALYSIS OF FAST BOWLING TECHNIQUES USED BY ELITE FEMALE CRICKETERS.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1386

[14]. Worthington, P. J., King, M. A., & Ranson, C. A. (2013). Relationships Between Fast Bowling Technique and Ball Release Speed in Cricket. In Journal of Applied Biomechanics (Vol. 29). www.JAB-Journal.com
[15]. Felton, P. J., Lister, S. L., Worthington, P. J., & King, M. A. (2019). Comparison of biomechanical characteristics between male and female elite fast bowlers. Journal of Sports Sciences, 37(6), 665–670. https://doi.org/10.1080/02640414.2018.1522700
[16]. Felton, P. J., Yeadon, M. R., & King, M. A. (2020). Optimising the front foot contact phase of the cricket fast bowling action. Journal of Sports Sciences, 38(18), 2054–2062. https://doi.org/10.1080/02640414.2020.1770407