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Mechanical Analysis of Overhead Throwing in Cricket

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Abstract. This paper considers the kinematic characteristics of over arm throwing with particular emphasis on the techniques of throwing in cricket. The technique is subdivided into: (1) Wind up phase, (2) late cocking Phase (3) arm acceleration and (4) instant of ball release. The study was used to form the samples as, 10 elite cricket players. The ages of the players were (mean ± 23.50). The physical characteristics of height (Mean: 1169.4-172.4cm)), weight (57.8-61.3). Each over head maximal and sub maximal successful attempt for each throwing distances 20m and 10m with 1800,1120 and 450 approach angle at 900 target angle from the stump were recorded using Sony DV cameras in a field setting with (1/2000 shutter speed and at 30-60fps). The cameras were set-up on a rigid tripod and secured to the floor in the location. First camera was located to obtain maximum accuracy and second camera located to view the throwing performances, at given specified distance in the reconstruction of the two dimensional co-ordinate. The location of camera were chosen so that the optical axes of camera intersected perpendicularly to the designated plane .The accuracy of throwing performances were considered in identify the footage for addition and were subjected to analysis. Result revealed that the ball speed had to be high to carry the full distance of the throw in the shortest time. Using a lower angle of release can further reduce flight time, as for the 20-m throw, for which a much flatter projection was used.

Keywords: cricket, sequential movements, two-dimensional analysis, projection throwing.

1. Introduction:

Cricket is one of the most popular sports in India. It is a game played by both male and female across many age groups and levels of participation from recreational to professional sports. In India, the game also is played at all levels from amateur to professional competitions. India has been adequately represented at both levels, from intercollegiate to world championship, in both junior and senior men and women categories.

In the cricket bowling, batting and fielding are three key skills, and much of the biomechanical research has focused on bowling and batting (Bartlett et al., 1996).Over arm throwing techniques, has been widely studied in other sports, including track and field (Best et al., 1993) and baseball (Escamilla et al., 1998). The limited research into the basic mechanisms underlying specific cricket throws highlights the need for more information directly applicable to the `elite' cricketer. Only Elliott and Anderson (1990) have tried to quantify, in three dimensions, the throwing technique adopted in cricket. They have concerned essentially with age-related differences in over arm throwing, not specifically the patterns of throwing in cricket. It has been shown that throwing is an important aspect of many sports and that a sound understanding of throwing technique can facilitate improvements in throwing performance (Fleisig et al., 1966). There is an increasing emphasis on good fielding in cricket; it could be that three or four quality fielders are as important as two bowlers who have the ability to take wickets. Fleisig et al. (1996) contended that, although there are similarities in all overhand throws, but have quantifiable differences in the mechanics for various sports.

Throwing may be performed along an overhead, sidearm, or underarm pattern in cricket. Critical fundamental throwing characteristics are common across the cocking, acceleration, and deceleration phases. The deceleration phase blocks the horizontal momentum of the trunk and provides an accurate release in addition to protecting against injury.

Over arm throwing is a fundamental movement skill that forms the cornerstone of many games (Elliott and Anderson, 1990); the development of this skill could be paramount for all cricket players. Biomechanics have helped in the development of throwing by analyzing and evaluating specific throwing techniques and identifying important characteristics of various types of over arm throw (Atwater, 1979). When throwing from any area of the cricket field, the fielder must be able to project the ball with accuracy and speed if aiming for a run-out and saving run, a prerequisite that may rely heavily on throwing technique, as suggested by Elliott and Anderson (1990). Analysis of throwing techniques in cricket has been the basis for many studies across a range of sports; these have served to identify important variables and characteristics of throwing performance.

2. Methodology:

The Subjects:

Ten (10) cricket players of Indian National and All-India Intervarsity level standards participated in this study, mean age (23.50 years ± 2.06), height (172.4 cm ± 5.98) and weight (61.3 kg ± 6.49). All the selected players have readily agreed and volunteered to act as subject for the study.

Selection of trails:

The subject have taken over head throws from marked spot at 90^0 angle from the stump/target situated at a distance of 10 m and 20 m. They have been instructed to follow approach angles (180^0,112^0 and 45^0) selected for research purpose. On each successful throws was selected on the basis of experts rating and qualitative analysis.

Videography Techniques

The video graphic technique was further organized in to two sections. These are:

(1) Video Graphic Equipments and Location

(2) Subject and Trail Identification

2.1. Vediographic Equipments and Location

The subject’s throwing motion were recorded using Canon Sf-10, 8.1 Mp video camera in a field setting operating at a nominal frame rate of 50 Hz and with a shutter speed of 1/2000 s *and at 30-60fps* camera in a field setting. The camera was set-up on a rigid tripod and secured to the floor in the location.

The camera was positioned perpendicular to the sagittal plane and parallel to the mediolateral axis (camera optical axes perpendicular on the sigittal plane) as their throwing arm giving approximately a 90^o between their respective optical axes. The camera was also elevated to 95 cms and tilted down in order to get the image of the subject as large as possible while that all points of interested remained totally within

2.2. Subject and trail Identifications

To identification the subject in the video graph, each subject was given with a numbers. as to distinguish in the data recorded. For identification purposes of a best throws, the trails were viewed on the computer system and exarter on the subject (thrower) demarketed the trail for the data acquisition. The successful throws were spotted, slashed and edited for analysis.

3. Data reduction:

After video recording sessions were over, the video recording was loaded in to the researcher’s personal computer (PC) for trail identification. The identified trails were played with the help of Silicon Coach Pro-7 software to make separate clips of each player. The separate clips were then opened on to the Silicon Coach Pro-7 software. The software has provision to analyze the angles, displacement, time, speed, acceleration and number of frames as in the feature.

Selection of frames for analysis:

The identified frame of cricket throws movement has been divide in to three components for analysis:

(1) Wind up Phase

(2) Late Cocking phase

(3) Acceleration phase.

The Wind up phase; defines as the throwing hand contact with the ball or the point of the maximum elbow extension at hand ball contact. Late cocking phase; the point just after the ball contact until the throwing hand reach up to the its maximum height or maximum shoulder abduction that the throwing hand just after the ball contact and the finish of the acceleration through phase till the throwing hand goes freely in to the air.

The each thrower performed 6 maximal and 1 sub maximal accurate throws with 180^0,112^0 and 45^0 angle of approaches from each 10 m and 20 m throwing distance were selected. All throws, with the exception of the maximal throws, were performed so as to project the ball to a target area in the least time, but with the greatest possible accuracy. Sub maximal conditions required the cricket ball thrower simply to return the ball to the target area with no emphasis on minimizing flight time. If characteristics of technique are essentially the same for both maximal and sub maximal throws.

4. Result:

The general purpose of this study was to determine if a common inter segmental coordinative pattern existed between over head throw, with the hopes of being able to make every throw look the same. Both qualitative and quantitative measures were used for data analysis.

Table 1: Linear Velocity (ms^{-1}) of different segment with different distance and angle of approach for best throws.

End-point		Approach 180^0 (20 m)	Approach 112^0 (20 m)	Approach 45^0 (20 m)	Approach 180^0 (10m)	Approach 112^0 (10m)	Approach 45^0 (10 m)	Sub-maximal Approach 180^0 (20 m)
Hip	Mean	1.5970	1.6060	1.7580	1.6970	1.8880	1.7940	1.4990
	Standard Deviation	0.37220	0.38208	0.43158	0.61570	0.56253	0.63640	0.55812
Shoulder	Mean	2.6740	2.7030	2.7270	2.4170	2.5740	2.6550	2.4280
	Standard Deviation	0.57816	0.78171	0.82554	1.04633	0.71118	0.86490	0.90922
Elbow	Mean	5.1330	4.3750	5.0590	5.0460	4.7190	4.9460	4.6770
	Standard Deviation	0.86237	1.64193	0.88617	1.21670	0.93719	0.93301	0.55080
Wrist	Mean	7.2470	5.6240	5.9450	6.0040	6.1280	6.4740	6.1250
	Standard Deviation	1.32621	1.02084	0.97935	0.97523	0.48939	0.84629	1.23271

The descriptive statistics on all measured includes in the study reveals the linear velocity of different joint with different distance and angle of approach for best throws (Table: 1). The means (M) score of hip joint different distance throws are highest 1.8880 at 112^0 angle of approach 10 m distance and lowest 1.4990 at 180^0 angle of approach 20 m distance sub maximal throws. The means (M) score of shoulder joint different distance throws are highest 2.7270 at 45^0 angle of approach 20 m distance and lowest 2.4170 at 180^0 angle of approach 10 m distance throws. The means (M) score of elbow joint different distance throws are highest 5.1330 at 180^0 angle of approach 20 m distance and lowest 4.3750 at 112^0 angle of approach 20 m distance throws. The means (M) score of wrist joint different distance throws are highest 7.2470 at 180^0 angle of approach 20 m distance and lowest 5.6240 at 112^0 angle of approach 20 m distance throws are reported.

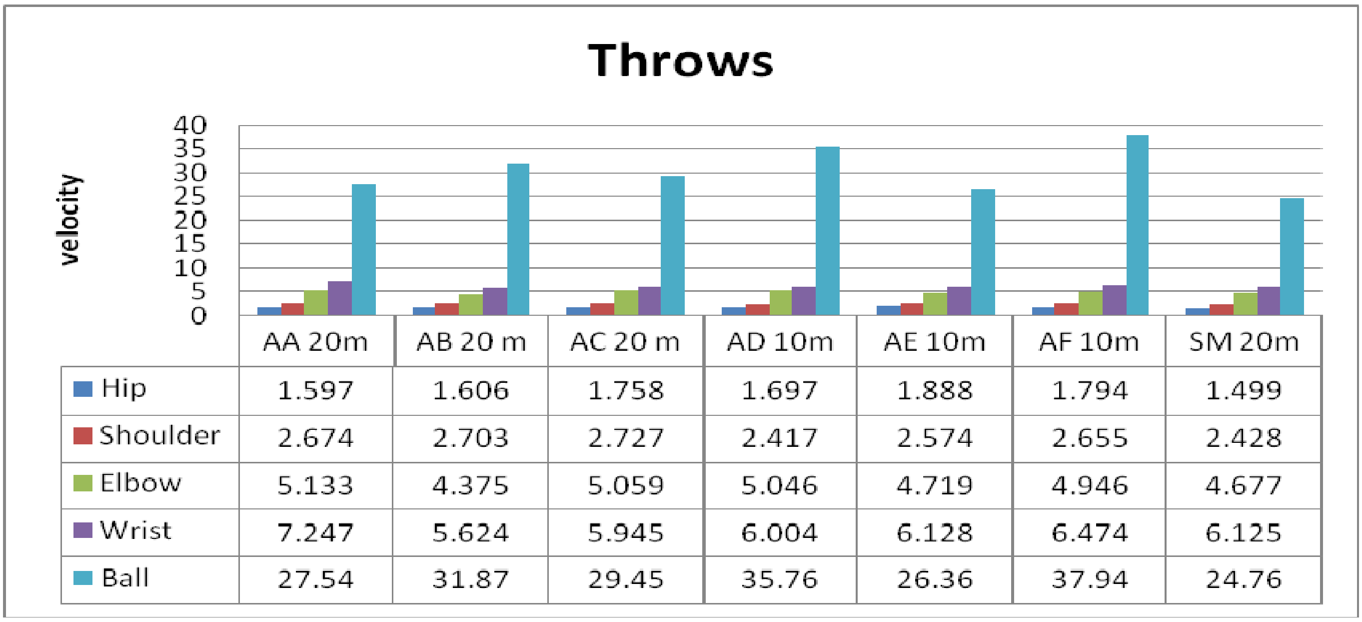

Fig. 1: Time taken to maximum segment endpoint speed (late cocking phase to ball release).

AA = Approach 180^0(20m), AB = Approach 112^0(20m) , AC = Approach 45^0(20) ,AD= Approach 180^0 (10m)
AE= Approach 112^0(10m) ,AF= Approach 45^0(10) SM = Submaximal Approach 180^0 (20m)

Table 2. Kinematic differences among best throws.

Perimeters	**Approach 180^0(20 m)**	**Approach 112^0(20m)**	**Approach 45 ^{0}(20m)**	**Approach 180^0(10m)**	**Approach 112^0(10m)**	**Approach 45^0 (10 m)**	**Submaximal Approach 180^0 (20 m)**
Wind up phase Stride length(% height) Elbow angle(^{0})	52 174	59 173	61 175	52 168	63 172	51 169	46 165
Late cocking phase Shoulder angle(Degree)	102	104	122	114	119	103	126
Acceleration phase Elbow angular velocity(.Deg/sec)	27.21	27.98	23.84	25.49	27.82	31.73	17.56
Instant of ball release Ball speed (m.s-1)	27.54	31.87	29.45	35.76	26.36	37.94	24.76

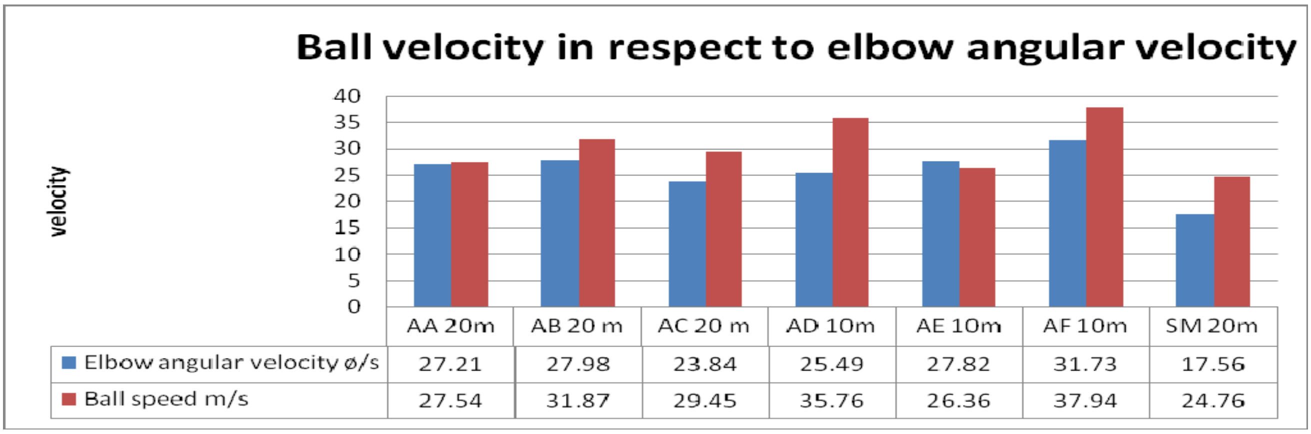

Fig. 2: Ball velocity taken to maximum elbow angular endpoint velocity (late cocking phase to ball release).

AA = Approach 180^0(20m)' AB = Approach 112^0(20m)' AC = Approach 45^0(20)' AD= Approach 180^0 (10m) AE= Approach 112^0(10m) ' AF= Approach 45^0(10) SM = Sub maximal Approach 180^0 (20m)

Table No. 2: Display that the descriptive statistics on all kinematics characteristics includes in the study reveals the stride length and elbow angle (wind up phase), shoulder angle (late cocking phase), elbow angular velocity (acceleration phase) and ball speed with different distance and angle of approach for best throws. The mean rang (M) score of throws with 180, 112^0 and 45^0angle of approach is stride length and elbow angle (wind up phase) M = (46±63 cm, 165^0±175^0 angle), shoulder angle (late cocking phase) M= (102^0±126^0 angle), elbow angular velocity (wind up phase) M= (17.56±31.73 deg/sec) and ball speed M= (24.76±37.94).

5. Discussion:

This study cited sequential profile, with the segments of the arm being coordinated in a proximal-to-distal fashion, culminating in a high endpoint speed at release. Maximal and sub maximal linear Velocity(ms^{-1}) of different joint with10 m and 20 m distance at 180^0, 112^0, and 45^0 angle of approach, linear velocity of hip (1.60± 1.70, 1.60±1.89 and 1.76ms^{-1}), shoulder (2.42±2.67, 2.57±2.70and 2.73ms^{-1}), elbow (5.045±5.13, 4.37±4.72and 4.95ms^{-1}) and wrist (6.00±7.25, 5.62±6.13and 6.47ms^{-1}). The results for this study indicate that he used a slightly different coordinated action when throwing over 20 m compared with 10 m distance, with maximum shoulder speed occurring before or at the instant of maximum hip speed.

Stride length of Wind up phase ranged from 51 to 63 of standing height, providing a stable base over which subsequent actions were performed. With one exception, the accuracy required of each thrower was more stringent than in the study of Atwater (1979) reported that stride length was approximately 65% of the height of a skilled male during a baseball throw, consistent with that for a high-speed over arm throw as a consequence, a shorter stride may have been used to enable a more `controlled' transition into the forward motion of the throw Furthermore, differences in stride length may be related to the different requirements of each throw, as was evident for the 20 m distance with 45^0 of approach angle , with the stride length accounting for only 51% of standing height. The aim of this throw is to return the ball accurately, ignoring speed, to the target area; as such it does not require a long stride. At this instant, elbow flexion of the throwing arm was large for all throws (165±175° included angle), in line with the values reported by Elliott et al. (1994). This difference may be explained by the nature of the throwing and pitching actions, with the throw in cricket incorporating more of a `preparatory arc' before acceleration, compared with a definitive withdrawing of the arm in throwing. The values shown in Table 6 illustrate that greater shoulder Angle was achieved when throwing (20 m) of distance with 45^0 approach angle. With the exception of the 20 m distance trial, the values for all throws were considerably lower than those reported in the baseball literature, ranging from 143 to 152°. The value reported for the (20 m) of distance with 45 ^{0} Approach Angle throw was greater than for all angle of approach with different distance throws , a result that was unexpected. The rapid extension was evident for all maximal throws, with higher values being recorded for throws from 20 m with 45^0 of approach angle.

Release speed was comparable for maximal throws over both distances: 26.36±35.76m´ s^{-1} over 10 m and 27.54±31.87m´ s^{-1} over 20 m. Similarly, Elliott et al. (1994) reported comparable ball release speeds for a catcher throwing to second base (33.3 m´ s^{-1}) and an outfielder throwing for maximum distance (34.2 m´ s^{-1}). Although the release speed reported for baseball was considerably greater than that observed in the present study, both sets of results indicate a speed and accuracy trade-of when throwing from the `outfield'. The results of the present study imply that a speed and accuracy occurs when throwing from 20 m, compromising speed to optimize accuracy.

6. Conclusion:

The findings of this study are similar to those ahead, reported for baseball; reveal that there is a definite crossover in the rationale of how an individual should throw specific to the claim of cricket and baseball. The throwing technique adopted by the participant used a highly coordinated sequential order of movements to achieve an efficacious throw. The lead leg was thrust forward and the ball was maneuvered to a position behind the body with the shoulder rotating externally, thereby initiating a stretch on the shoulder musculature. During the subsequent shortening phase, the throwing arm was actively accelerated from this position through to ball release as the elbow extended expeditiously. The release characteristics were largely determined by the aim of the throw. Ball speed had to be high to carry the full distance of the throw in the shortest time. Using a lower angle of release can further reduce flight time, as for the 20-m throw, for which a much flatter projection was used. The differences that were evident between previous research and the present case study and greater elbow flexion at lead foot contact and less external rotation during the preparation phase and can be attributed to the demands placed on the fielder and pitcher specific to their respective sports. The pitcher in baseball has minimal time constraints relative to the cricketer, who tries to achieve a run-out.

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