*Available online at* www.scholarsresearchlibrary.com

Scholars Research Library

**Annals of Biological Research, 2014, 5 (4):62-67**
*(http://scholarsresearchlibrary.com/archive.html)*

ISSN 0976-1233
CODEN (USA): ABRNBW

# Biomechanical analysis of force production during under-arm throwing techniques in cricket

**Syed Ibrahim[1], Mohammed Arshad Bari[2] and Ikram Hussain[2]**

*[1]Physical Education Department, King Fahd University of Petroleum and Minerals, Dhahran, KSA*
*[2]Department of Physical Education, Aligarh Muslim University, Aligarh (U.P) India*

---

**ABSTRACT**

*10 cricketers representing Aligarh University in the North-Zone inter university cricket tournament were selected as subjects for this study. The subjects were asked to make under-arm throws from marked spot at $90^0$ angle from the stump/target situated at a distance of 10 m. All the subjects were instructed to follow to take first step run with approach angles ($180^0$). Successful throws were selected on the basis of experts rating and qualitative analysis. The variable analyzed were velocity, acceleration, force and the angle of the wrist joint to that of the force model when under arm throws were made. The subject's under arm throwing movements were recorded using Canon Legria SF-10, 8.1 Mp video camera in a field setting operating at a nominal frame rate of 50 Hz and with shutter speed of 1/2000 s and at 60fps camera in a field setting. The camera was set-up on a rigid tripod and secured to the floor in the location. From that, the data for velocity, acceleration, angle of wrist and distance when throwing were asserted. The data was subjected to Biomechanical analysis with the application of Silicon Coach Pro-7 and Statistical Package for the Social Sciences (SPSS-18). The equation that related with the variables was identified according to the result from SPSS-18 table of summary for regression model, ANOVA of regression model and coefficient of regression model for each variable. This study will help the cricket teams to create and determine the best and possible solution to enhance their throwing skills.*

**Keywords:** Biomechanics, kinematics, acceleration, velocity, angle, force

---

## INTRODUCTION

Throwing is a fundamental movement skill that forms the cornerstone of many games and the development of this skill could be of paramount importance for some athletes [7]. Not only appropriate physical movements are important in ball throwing, but proper sense also plays an important role. In the technique of under arm throwing a thrower must be able to execute the skill accurately. The numerous aspects of throwing make it a complex skill to gain expertise, and therefore generally follow different predictable stages. The theoretical concept have conclusively defines that elite sportsmen of skilled levels exhibit mechanical variability.

The biomechanical analysis of throwing technique is the response to full fill existential vacuum, refinement, and stabilization of the game and sports arising in the competitive sporting world to the changing demand at the international level of competition where a minute variation may result in win or loss. Every nation is backing their sports person with biomechanical researches to accomplish the much needed fillip to climb higher ladder of performance [5].

The developing countries have incorporated changes according to the demand and thus superseded the global level of performance. In this context the game cricket also needs support from researchers to identify variation and variables to steer their performance and optimize it to greater heights. The objective of the present investigation was to produce vital information on the segment interaction and force production during under arm throwing technique, which in turn would permit a better understanding of the factor that affect the motion of the throwing arm during under arm cricket ball throwing. Hence, the present research has been under taken to find out under arm throwing techniques in relation to biomechanical aspect of high skilled cricket players.

## MATERIALS AND METHODS

**2.1 The Subjects:**
Ten (10) cricket players of Intervarsity level participated in this study, with mean age (21.90± 3.63), height (171± 4.50) and weight (60.30± 7.17). All the selected players had readily agreed and volunteered to act as subject for the study.

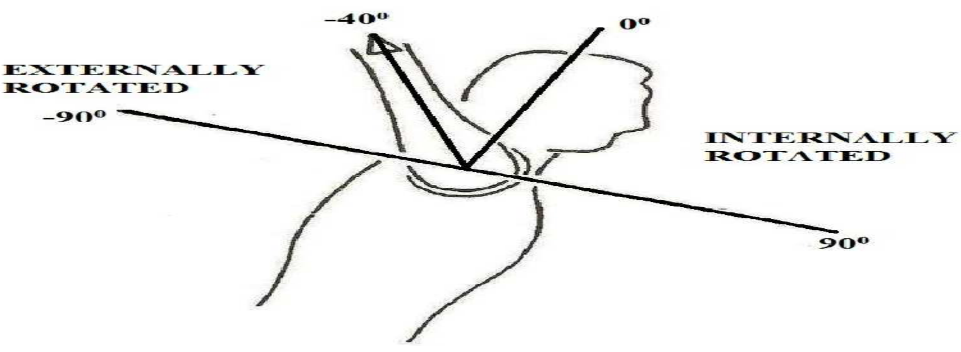
**2.2 Selection of trails:**
The subject had taken under-arm throws from marked spot at $90^0$ angle from the stump/target situated at a distance of 10 m. They had been instructed to follow approach angles ($180^0$) selected for research purpose. Each thrower performed 03 accurate throws with $180^0$ angle of approaches from 10 mts. throwing distance. The best throw among the 03 was selected on the basis of expert rating through qualitative analysis.

**2.3 Videography Techniques:**
The video graphic technique was further organized into two sections in the following manner:
(i) Video Graphic Equipment and Location
(ii) Subject and Trail Identification

**2.3.1 Vediographic Equipment and Location:**
The subject's throwing motion were recorded using Canon SF-10, 8.1 Mp video camera in a field setting with a shutter speed of 1/2000 s and at 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 Medio lateral axis (camera optical axes perpendicular on the sagittal plane) as their throwing arm giving approximately $90^o$ 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 all the points of interest remained within the range.

**2.3.2 Subject and trail Identifications:**
To identify the subject in the video graph, each subject was allotted a number, so as to distinguish in the data recorded. To identify best throws, the trails were viewed on the computer and the subjects were distinguished in the trail for the data acquisition. The identified successful throws were spotted, slashed and edited for analysis.

**2.4 Data reduction:**
After video recordings and trail identification, the identified trails were played in Sony Vegas-10 software to make separate clips as well as rendering the data of each player. Separate clips were then opened on to the Silicon Coach Pro-7 software for analysis. The software has provision to analyze the angles, displacement, time, speed, acceleration and number of frames as in the feature.




Under arm throwers who have a flexed elbow during the latter stages of throwing carry the ball in the hand for some distance from the upper arm internal rotation axis, providing the opportunity to take advantage of this segmental rotation to contribute to ball speed. A two-link model representing the upper arm and forearm was used to compare the wrist/ball speed produced by a straight or a flexed throwing arm during throws [4]. Thus, to the ball speed contribution formula we now add the upper arm angular velocity (internal rotation) (ώ IR) times the ball-internal rotation axis distance (ώ D). However, since a flexed elbow also decreases the shoulder-wrist distance (rf< TA), it is necessary to consider the reduction in the contribution to ball speed from the arm's angular flexion velocity (ώ A)

## RESULTS

The resultant arm length (rA) decreases as the flexion angle ($^0$) is increased whereas the effective wrist-internal rotation axis distance (d) increases (Table 3). With an increase in elbow flexion angle to 60°, the resultant arm length decreases minimally (0.410 m) while distance d increases to 0.201 m.

**Table-I Kinematics of Wrist Angle During Under-Arm Throwing Phase by Phase**

| **Kinematics of Wrist Angle During Under-Arm Throwing Phase by Phase.** | | | | |
|---|---|---|---|---|
| **Phases** | **X-axis(Angle)** | **Y-axis(Angle)** | **Delta time (s)** | **Measurement (°)** |
| 1- Phase | 148 | 362 | 0 | 144.90 |
| 2- Phase | 164 | 361 | 0 | 131.71 |
| 3- Phase | 213 | 347 | 0 | 101.99 |
| 4- Phase | 247 | 316 | 0 | 149.55 |
| 5- Phase | 277 | 302 | 0 | 173.30 |
| 6- Phase | 314 | 310 | 0 | 170.32 |
| 7- Phase | 358 | 321 | 0 | 158.93 |
| 8- Phase | 377 | 339 | 0 | 123.40 |

**Table-II Kinematics of Wrist during Under-Arm throwing Phase by Phase at scale 108 pixels per Meters**

| **Continuous distance** | **Continuous distance** | **Scale 108 pixels per Meters** | | | | | |
|---|---|---|---|---|---|---|---|
| X-axis | Y-axis | Abs time (s) | Delta time (s) | Measurement (m) | Cumulative measurement (m) | Speed (m/s) | Acceleration |
| 253 | 285 | 1.28 | 0 | 0 | 0 | 0 | 0 |
| 294 | 259 | 1.34 | 0.060 | 0.451 | 0.45 | 7.68 | 5.29 |
| 342 | 243 | 1.40 | 0.059 | 0.470 | 0.92 | 11.09 | 108.41 |
| 433 | 260 | 1.46 | 0.060 | 0.861 | 1.78 | 13.81 | -17.97 |
| 516 | 281 | 1.52 | 0.059 | 0.796 | 2.58 | 16.53 | 108.62 |
| 641 | 307 | 1.58 | 0.060 | 1.187 | 3.77 | 14.59 | -173.04 |
| 701 | 316 | 1.64 | 0.060 | 0.564 | 4.33 | 12.15 | 91.70 |
| 796 | 331 | 1.70 | 0.060 | 0.894 | 5.22 | 0 | 0 |

**Table III- The Resulting Shoulder-Wrist Distance and the Effective Wrist-Internal Rotation Axis Distance as a Result of Elbow Flexion**

| **Elbow flexion Angle degree** | **Resultant throwing arm length (m)** | **Effective wrist-IR axis distance (m)** |
|---|---|---|
| Degree ($^\theta$) | Mean | Mean |
| 00 | 0.473 | 0.000 |
| 10 | 0.463 | 0.042 |
| 20 | 0.452 | 0.061 |
| 30 | 0.440 | 0.098 |
| 40 | 0.427 | 0.117 |
| 50 | 0.418 | 0.142 |
| 60 | 0.410 | 0.201 |

As $^\theta$ is changed from 0° to 60° the increase in wrist speed due to internal rotation at either 1150 $^0$/s or 2200 $^0$/s becomes increasingly greater than the loss in wrist linear velocity due to a decrease in forearm length. Few authors have reported angular velocities of the arm for throwing, although calculations based on the data in the review Journal [1] which suggest a value of approximately (30 r/s) is required to produce the recorded ball speeds. The studies of [2] and [3] have reported upper arm internal rotation speeds of about (100 r/s) in baseball pitching. Note that the internal rotation speeds achievable are influenced by the mass of the ball being thrown.

### 3.1 Least squares, regression analysis:

The methods of least squares and regression analysis are conceptually different. However, the method of least squares is often used to generate estimators and other statistics in regression analysis. Consider a simple example drawn from physics. A under arm throwing arm should obey Hooke's law which states that the flexion of a throwing arm is proportional to the force, *F*, applied to it.

$$F\,(F_i, k) = k\,F_i$$

Constitutes the model, where *F* is the independent variable. To estimate the force constant, *k*, a series of *n* measurements with different forces will produce a set of data, $(F_i, y_i)$, $i = 1, n$ where $y_i$ is a measured arm flexion. Each experimental observation will contain some error. If we denote this error ε, we may specify an empirical model for our observations,

$$y_i = kF_i + \varepsilon_i.$$

There are many methods we might use to estimate the unknown parameter *k*. noting that the *n* equations in the *m* variables in our data comprise an over determined system with one unknown and *n* equations, we may choose to estimate *k* using least squares. The sum of squares to be minimized is

$$S = \sum_{i-1}^{n} (y\,i - k\,Fi)^2$$

The least squares estimate of the force constant, *k*, is given by

$$K = \sum_i F_i\ Y_i / \sum_I F_i^2$$

One of Newton’s laws was that force equals mass multiplied by acceleration. We already know that the ball is about 0.16 kg. Now, we just need to find the acceleration of the ball, which is the change in velocity of the ball.

The force acting on the ball is the mass of the ball, 0.16 kg, multiplied by the acceleration. Considering the Newton’s third law, in which every force is balanced by an equal but opposite force, so the same amount of force would be acting on the player’s arm as well as on the ball. If we want to convert this amount to a weight, we would look for what mass would have this as its weight. The weight of a mass *m* kilogram is 9.8*m*.

### 3.2 Regression analysis:

**3.2.1 Velocity:** Table 4 shows a regression model for velocity. The productivity regression model, $R^2$ as the coefficient of the multiple determinations for the productivity regression model, $R^2 = 1.00$ and the output reports R2 × 100% = 100%. This can be interpreted as indicating that the model containing velocity for approximately 100% of the observed variability in force.

**Table 4: Summary of regression for velocity**

| Model | R | $R^2$ | Adjusted $R^2$ | Std. error of the estimate |
|---|---|---|---|---|
| 1 | 1.00 | 1.00 | 1.00 | 0.1342 |

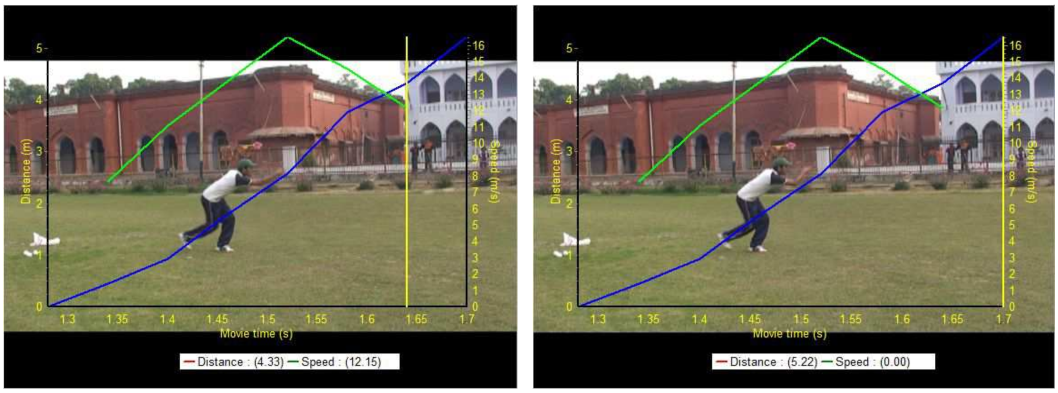



**Figure I :The basic throwing technique (right-handed cricket player) have many characteristics: the run-up, wind-up phase, left foot contact, throwing arm rotation, late- cocking phase, acceleration phase, ball release, and follow-though in respect to cricket ball velocity phase by phase**

For a straight throwing arm, ball velocity (BVe) can be considered to be the sum of the linear velocity of the shoulder (LVSh) plus the linear velocity of the hand (LVh) plus the linear velocity of the wrist (LVWr) resulting from arm motion (ῳA Am) as a result of hand flexion (ῳAHf) (Figure 2). This analysis examines the changes to the LVwr component of ball speed as a result of elbow flexion. We assume changes to wrist speed would have the same effect on ball speed for both straight and flexed elbow deliveries.

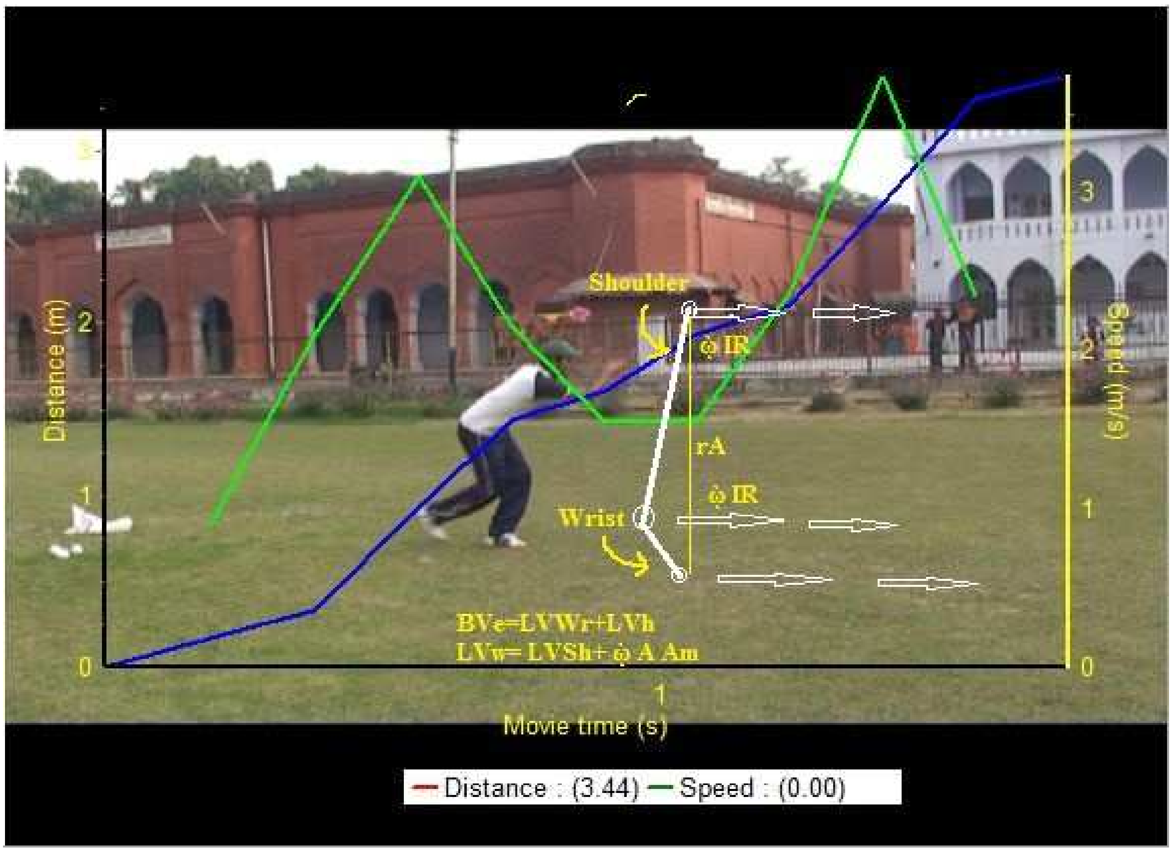



**Figure-II.The throwing arm represented as a simple two-link model, showing the contribution of arm and hand flexion angular velocity to wrist and ball velocity**

**3.2.2 Force:** The force acting on the ball is the mass of the ball, 0.16 kg, multiplied by the acceleration, 1234.15 m/s$^2$, which is 197.464 kg tm/s$^2$ per second squared. If we want to convert this amount to a weight, we would look for what mass would have this as its weight. The weight of mass m kilograms is 9.8*m*, so we want 9.8*m* = 197.464. This means *m* = 197.464/9.8 = 20.14 kg. So a professional University cricket player would experience a force on his arm during under arm throwing at 10m distance that would likely to be weight of 20.14 kg.

## DISCUSSION

The highest average force is 4936.00 N and 197.464 kilograms times' meters per second squared at 17.25 m sec$^{-1}$ average velocity. Other than that, the objective to come out with one force equation which cover all the parameters involved has been done using SPSS software which includes some assumption.

Under arm cricket thrower do not hold a flexed elbow during the starting phase of delivery. This effectively invalidates the possible contribution of upper arm internal rotation, which is a major subscriber to ball or racquet speed in most other throwing [6]. From our calculations, thrower using a flexed elbow during delivery may be able to produce a clear-cut advantage when originating wrist speed. The generation of wrist speed via upper arm internal rotation significantly outweighs any loss of wrist speed due to a reduction in effective bowling arm length. The range of elbow angles (0-60°) used and the slow internal rotation speed gain in wrist speed (and therefore ball speed) was between 0.89^124 m/s). Internal rotation speed is limited by the mass of the ball, and thus one would expect greater internal rotation speeds than this during the under arm throws of a cricket ball. Therefore, it does not matter whether a bowler consciously maintains a flexed elbow during delivery, nor has an elbow deformity either of the fixed flexion or carry angle type — both provide the potential for substantially increased wrist and ball speed through the use of internal rotation of the upper arm.

## CONCLUSION

It was concluded that the internal rotation of the upper arm increases the wrist and ball speed irrespective of the player keeping a flexed elbow or is effected by elbow deformity while attempting an under arm throw in cricket.

.

## REFERENCES

[1] Bartlett, R. M., Stockill, N. P., Elliott, B. C., & Burnett, A. F., *Journal of Sports Sciences*, **1996**, vol. 14: 403-424.
[2] Elliott, B. & Anderson, G., *Journal of Human Movement Studies*,**1996**, vol. 18: 1-24.
[3] Feltner, M. &Dapena, J., *International Journal of Sport Biomechanics*,**1986**, vol. 2 (4): 235-260.
[4] Hussain, I., Bari M.A., Khan, A., & Mohammad A. Ahmad A., *International Journal of Sports Science and Engineering*,**2011**, Vol. 05, 1, 043-048.
[5] Lucas McKay,J and Lena H. Ting., *PLOS Computational Biology*, **2011**,8(4).
[6] Marshall, R. N., and Elliott, B. C., *Journal of Sports Sciences*, **2000**,18, 247-254.
[7] Solum, J.,*Science of shooting - water polo fundamentals* (1st ed.) Los Angeles, California, USA, **2010**.