Innovative Systems Design and Engineering www.iiste.org
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol 2, No 3

Biomechanical Analysis of Flex Elbow on Bowling Speed in Cricket

Ikram Hussain
(Professor and Chairman)
Department of Physical Health and Sports Education,
Aligarh Muslim University, Aligarh, 202002, (U.P.), India.
E-mail: ikram.husain@gmail.com

Mohd. Arshad Bari
(Lecturer)
Corresponding author
Department of Physical Health and Sports Education,
Aligarh Muslim University, Aligarh, 202002, (U.P.), India.
E-mail: sbiomech90@gmail.com

Mohd. Imran
Department of Physical Health and Sports Education,
Aligarh Muslim University, Aligarh, 202002, (U.P.), India.
E-mail: imranphe09@yahoo.com.in

The authors would like to acknowledge the cooperation of UGC-SAP (DRS-I) Programme, Department of Physical Health and Sports Education, Aligarh Muslim University, Aligarh

Abstract

Bowling in cricket is traditionally thought to be a rigid-arm motion, allowing no elbow straightening during the delivery phase. Conversely, research has shown that a perfectly rigid arm through delivery is practically unattainable, which has led to rule changes over the past years. The current rule requires a bowler not to increase the elbow angle by more than 158, thus requiring a measurement to confirm legality in “suspect” bowlers. This study examined whether such bowlers can produce an additional contribution to wrist/ball release speed by internal rotation of the upper arm. The kinematics of a bowling arm were calculated using a simple two-link model (upper arm and forearm). Using reported internal rotation speeds of the upper arm from baseball and bowling arm kinematics from cricket, the change in wrist joint speed was analysed as a function of effective arm length, and wrist distance from the internal rotation axis. A significant increase in wrist speed was noted. This suggests that bowlers who can maintain a fixed elbow flexion during delivery can produce distinctly greater wrist/ball speeds by using upper arm internal rotation.

Keywords: kinematics, biomechanics, bowling, cricket, elbow flexion.

1. Introduction

The resolve of bowling in cricket is to deliver the ball to the batter so that the ball is hard for the batsman to counter, either through its speed or spin. Most bowlers commence with a smooth, rhythmical run-up to generate linear momentum which is channelized during the delivery stride to propel the upper body over the front leg. This activity generates the angular velocity of the bowling arm as it circumducts the glenohumeral joint. It is proposed that the development of wrist speed is equally important to spin and fast bowlers, in that it lends to the angular or linear speeds of the ball respectively.

The fast bowling action can be classified as side-on, front-on, semi-front-on or mixed depending on the orientation of the shoulder, hip axes and back foot alignment during delivery. Bowlers who use the side-on and front-on techniques are not at as much risk of injury as those who use the mixed technique. The semi-front-on action is a new technique that is based on the same principles as the two `safe actions', where the alignment of the shoulders and hips are in the same direction. The mixed action features a realignment of the shoulders in the transverse plane during the delivery stride, which causes an increase in lumbar spine axial rotation, extension± flexion and lateral flexion. All these features occur cumulatively in a very short time when ground reaction forces are high. A combination of these factors has been linked to an increased incidence of radiological features in the thoracolumbar spine, including spondylolysis, intervertebral disc degeneration and spondylolisthesis (Foster *et al.*, 1989; Elliott *et al.*, 1992; Burnett *et al.*, 1996). Spondylolisthesis was reported in 50% of A-grade fast bowlers over a period of 5 years by Payne *et al.* (1987) and has been found to represent 45% of bony abnormalities reported by retired, elite fast bowlers (Annear *et al.*, 1992).

Biomechanical evaluation supports the claim that he maintains a constant elbow flexion angle throughout delivery (Lloyd *et al.*, 2000). Elbow flexion is not only restricted to spin bowlers. In the past, fast bowlers such as Ian Meckiff (Australia) and Charlie Griffith (West Indies) were considered by some to bowl with a flexed elbow. Recently, however, the whole issue of elbow flexion in fast bowling has re-emerged after the two of theworld's fastest bowlers, Shoaib Akhtar (Pakistan), Imtiaz Ahmed (India) and Brett Lee (Australia), were cited by umpires for a possible infringement of the bowling law. The use of internal rotation of the upper arm in cricket bowling to assist in the development of wrist/ball speed has not been examined and it appears some bowlers may utilise this technique. Previous work (Elliott *et al.*, 1995; 1996; 1997) has clearly shown the importance of upper arm internal rotation in contributing to racquet-head speed in tennis and squash. Further, Marshall and Elliott (2000) suggested that internal rotation was a significant factor in most overarm throwing or striking activities. The purpose of this study is to investigate the mechanics of bowling with a flexed elbow, and to determine whether there is any advantage with respect to wrist/ball speed in doing so.

2. Methodology:

Six (06) cricket players from Narashans Cricket Academy (NCA), Aligarh were randomly selected for the purpose of the study. They performed bowling during training session. The mean age of the cricket players were age (18.98 years), height – (167.87 cm.), weight (53.29 kg.). For the acquisition of kinematical data, the subject's throwing motion were recorded using Canon Legaria SF-10, 8.1 Mp video camera in a field setting operating at a nominal frame rate of 60 Hz and with a shutter speed of 1/2000 s *and at 60fps* . The camera was set-up on a rigid tripod and secured to the floor in the location at a distance of 12 meter from the point of throw. 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 within one frame.

The recorded video footages were downloaded, slashed and edited by using the downloaded version of STHVCD55, Sony Vegas pro- 10software. Digitization, smoothing and analysis were conducted using the Silicon Coach Pro7 motion analysis software.

Figure 1 The basic bowling technique (right-hand bowler) has many characteristics: the run-up, leap, right foot contact, left arm motion, bowling arm rotation, left foot contact, ball release, and follow-though in respect to wrist linear velocity phase by phase.

For a straight bowling 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 wrist (LVWr) resulting from arm motion ($\dot{\omega}$A Am) plus the linear velocity of the hand (LVh) as a result of hand flexion ($\dot{\omega}$A Hf) (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.

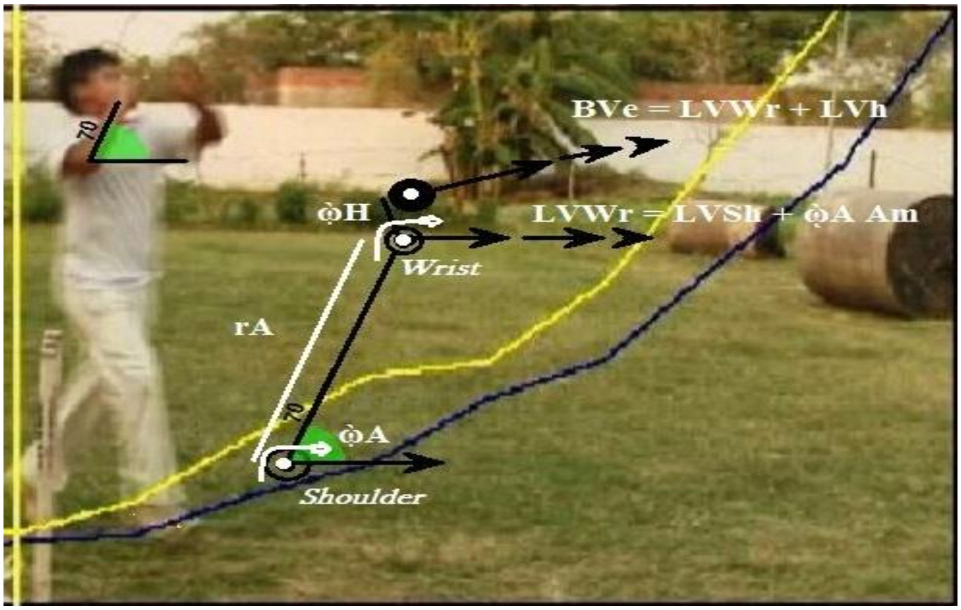

Figure 2. The bowling arm represented as a simple two-link model, showing the contribution of arm and hand flexion angular velocity to wrist and ball velocity.

Bowlers who have a flexed elbow during the latter stages of delivery carry the ball in the hand at 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 bowling arm during delivery. Thus, to the ball speed contribution formula we now add the upper arm internal rotation angular velocity (ῳ IR) times the ball-internal rotation axis distance (ῳ 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 (ῳ A).

3. 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 1). With an increase in elbow flexion angle to 35°, the resultant arm length decreases minimally (0.043 m) while distance d increases to 0.167 m.

Table 1 The Resulting Shoulder-Wrist Distance and the Effective Wrist-Internal Rotation Axis Distance as a Result of Elbow Flexion.

Elbow flexion Angle degree	*Resultant bowling arm length (m)*		*Effective wrist-IR axis distance (m)*	
Degree ($_0$)	**Mean**	**SD**	**Mean**	**SD**
00	**0.473**	**0.027**	**0.000**	**0.000**
05	**0.470**	**0.028**	**0.022**	**0.015**
10	**0.463**	**0.023**	**0.040**	**0.024**
15	**0.459**	**0.022**	**0.060**	**0.030**
20	**0.452**	**0.023**	**0.068**	**0.026**
25	**0.445**	**0.016**	**0.093**	**0.036**
30	**0.440**	**0.023**	**0.135**	**0.052**
35	**0.433**	**0.022**	**0.167**	**0.049**

As $_0$ is changed from 5° to 35° the increase in wrist speed due to internal rotation at either 1950 ^{0}/s or 4600 ^{0}/s becomes increasingly greater than the loss in wrist speed due to a decrease in forearm length. For example, with an elbow flexion of 35°, the loss in wrist speed due to the decrease in rf is 1.20 m/s while the gain from the use of internal rotation could be between 4.71 m/s and 11.34 m/s. Few authors have reported angular velocities of the arm for bowling, although calculations based on the data in the review by Bartlett *et al.* (1996) suggest a value of approximately 1700 7s (30 r/s) is required to produce the recorded ball speeds. Vaughn (1985) and Feltner and Dapena (1986) have reported upper arm internal rotation speeds of about 5700 7s (100 r/s) in baseball pitching and Feltner and Nelson (1996) reported internal rotation speeds of 2000 7s (35 r/s) in a waterpolo throw. Note that the internal rotation speeds achievable are influenced by the mass of the ball being thrown, and thus it might be expected that bowlers would achieve speeds closer to those of baseball pitchers than water polo players.

4. Discussion

Most bowlers do not hold a flexed elbow during the second stages 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 (Marshall and Elliott, 2000). From our calculations, bowlers 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 (5-35°) used and the slow internal rotation speed of 1950 °/s the net gain in wrist speed (and therefore ball speed) was between 0.72^136 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 delivery of a cricket ball. While speeds equivalent to baseball pitching might not be generated, it is likely the gains in speed would be greater than those suggested above. Therefore, it does not matter whether a bowler consciously maintains a flexed elbow during delivery, or 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.

REFERENCES

Annear, P.T., Chakera, T.M., Foster, D.H. and Hardcastle, P.H. (1992). Pars interarticularis stress and disc degeneration in cricket' s potent strike force: The fast bowler. Australian New Zealand Journal of Surgery, **62**, 768± 773.

Bartlett, R. M., Stockill, N. P., Elliott, B. C., and Burnett, A. F. (1996). The biomechanics of fast bowling in men's cricket: a review. Journal of Sports Science, 14, 403-424.

Biddle, S., Morris, P., de Looy, A., and Thomas, P. (1991). Get ready for cricket. A complete training programme. Wiltshire: The Crowood Press Ltd.

Burnett, A.F., Elliott, B.C. and Marshall, R.N. (1995).The eþ ect of a 12-over spell on fast bowling technique in cricket. Journal of Sports Sciences, **13**, 329± 341.

Burnett, A.F., Khangure, M.S., Elliott, B.C., Foster, D.H., Marshall, R.N. and Hardcastle, P.H. (1996). Thoracolumbar disc degeneration in young fast bowlers in cricket: A follow-up study. Clinical Biomechanics, **11**, 305± 310.

Elliott, B., Marshall, R., and Noffal, G. (1995). Contributions of upper limb segment rotations during the power serve in tennis. Journal of Applied Biomechanics, 11, 433-442.

Elliott, B., Marshall, R., and Noffal, G. (1996). The role of upper limb segment THE EFFECT OF A FLEXED ELBOW ON BOWLING SPEED IN CRICKET 71 rotations in the development of racquet-head speed in the squash forehand. Journal of Sports Sciences, 14, 159-165.

Elliott, B., Takahashi, K., and Noffal, G. (1997). The influence of grip position on upper limb contributions to racquet head velocity in a tennis forehand. Journal of Applied Biomechanics, 13, 182-196.

Elliott, B.C., Hardcastle, P.H., Burnett, A.F. and Foster, D.H. (1992). The in¯ uence of fast bowling and physical factors on radiological features in high performance young fast bowlers. Sports Science, Training and Rehabilitation, **3**, 113± 130.

Feltner, M. E., and Dapena, J. (1986). Dynamics of the shoulder and elbow joints of the throwing arm during a baseball pitch. International Journal of Sport Biomechanics, 2, 235-259.

Feltner, M. E., and Nelson, S. T. (1996). Three-dimensional kinematics of the throwing arm during the penalty throw in water polo. Journal of Applied Biomechanics, 12, 359-382.

Fleisig, G.S., Barrentine, S.W., Escamilla, R.F. and Andrews, J.R. (1996). Biomechanics of overhand throwing with implications for injuries. Sports Medicine, **21**, 421± 437.

Foster, D.H., John, D., Elliott, B.C., Ackland, T. and Fitch, K. (1989). Back injuries to fast bowlers in cricket: A prospective study. British Journal of Sports Medicine, **23**, 150± 154.

Lloyd, D., Alderson, J., and Elliott, B. (2000) Biomechanics in testing the legality of a bowling action in cricket. In Y. Hong and D.P. Johns (eds.), Proceedings of XVIII International Symposium on Biomechanics in Sports (pp. 875-877). Hong Kong: The Chinese University of Hong Kong.

Marshall, R. N., and Elliott, B. C. (2000). Long-axis rotation: The missing link in proximal-to-distal segmental sequencing. Journal of Sports Sciences, 18, 247-254.

Martin, A.D., Carter, J.E., Hendy, K.C. and Malina, R.M. (1988). Segment lengths. In Anthropometric Standardization Reference Manual (edited by T.G. Lohmann, A.F. Roche and R. Martorell), pp. 9± 26. Champaign, IL: Human Kinetics.

Miller, D.I. and Nelson, R.C. (1973). Biomechanics of Sport. Philadelphia, PA: Lea & Febiger. Minitab Inc. (1995). MINITAB Reference Manual. State College, PA: Minitab Inc.

Morriss, C.J. and Bartlett, R.M. (1996). Biomechanical factors critical for performance in the men' s javelin throw. Sports Medicine, **21**, 438± 446.

Munro, B.H. (1997). Statistical Methods for Health Care Research. Philadelphia, PA: Lippincott-Raven. Payne, W.R., Hoy, G., Laussen, S.P. and Carlson, J.S. (1987). What research tells the cricket coach. Sports Coach, **10**, 17± 22.

Plagenhoef, S. (1971). Patterns of Human Movement. Englewood Cliþ s, NJ: Prentice-Hall.

Ross, W.D. and Marfell-Jones, M.J. (1991). Kinanthropometry. In Physiological Testing of the High-Performance Athlete (edited by J.D. MacDougall, H.A. Wenger and H.J. Green), pp. 223± 308. Champaign, IL: Human Kinetics.

Stockill, N.P. and Bartlett, R.M. (1992a). Progress report on the National Cricket Association Sport Science Support Programme fast bowling project. Cricket Coach, **22**, 1165± 1172.

Vaughn, R. E. (1985). An algorithm for determining arm action during overarm baseball pitches. In D.A. Winter, R.W. Norman, R.P. Wells, and A.E. Patla (eds.), Biomechanics IX-B (pp. 510-515). Champaign, IL: Human Kinetics