CHAPTER - III

METHODOLOGY

In almost every sports and games the kinetic and kinematic principles have a great role to play. Cricket is one of the most popular sports in the world and this game involves lots of skill. Bowling is one of the important skills in this game. Although several factors influence the ability to bowl fast (e.g. technique, physical fitness, psychological skills, social factors), the National Cricket Association (NCA) regard technique as the most important (Stockill and Bartlett, 1992a). Recent scientific research has focused on the incidence and pathology of debilitating thoracolumbar spinal and intervertebral disc injuries. Although certain physiological and kinanthropometric characteristics have been suggested to relate to back injury, only biomechanical factors have been statistically linked to an increased incidence of injury. The emphasis of this paper is on technique and optimal ball release speed. A key theoretical principle that has yet to be fully explored in fast-medium bowling, but which is integral to many overhead throwing activities, is the 'kinetic chain' (Atwater, 1979). This phenomenon is defined as a proximal-to-distal linkage system through which energy and momentum are transferred sequentially, achieving maximum magnitude in the terminal segment (Fleisig et al., 1996). The acceleration of the segments with large moments of inertia facilitates eccentric contractions of the musculature surrounding the distal segments just before they contract concentrically (Joris et al., 1985). Because of the work done by the proximal muscle groups, the distal
muscles will contract over joints with increased strain energy, creating maximum possible forces in the distal muscles (Morris and Bartlett, 1996).

There is agreement among researchers as to the importance of ball release speed in fast bowling, but no consensus exists in the scientific literature on the elements of the bowling technique that contribute most (Bartlett et al., 1996a). Additionally, no study to date has tried to quantify the influence of various anthropometric variables on ball release speed. Thus, the main aim of this study was to identify significant relationships between selected body dimensions and kinematic variables and ball release speed.

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. In this chapter the design of study, procedure adopted to select the subjects, selection of variables, reliability of data, testers competency, procedure including the data collection and statistical techniques employed for the analysis of data are explained.

**Selection of Subjects**

The subjects selected for the study was Thirty male cricketers (N=30). The selected subjects were specialized bowlers who had represented the states of Kerala and Madhya Pradesh. The pace of the selected bowlers ranged from medium fast to fast. The age group of the subjects ranged from 22 years to 27
years. The prerequisites for selection included the ability to release the cricket ball at a speed classified as fast or fast-medium. Informed consent was obtained in accordance with the guidelines of the State Cricket Association. Ethical clearance was obtained from the local ethics committee.

**Experimental protocol**

The participants were instructed to undertake a cricket related warm-up activity of their choice. Each bowler was allowed an over (6 balls) of practice deliveries to aid familiarization with the test environment. An over at maximum effort was then bowled. The trial that resulted in the greatest release speed was selected for kinematic analysis based on the assumption that movement patterns were optimized. All deliveries were bowled with a S G Test cricket ball compliant with BCCI specifications (mass of 0.156± 0.163 kg and circumference of 0.224± 0.229 m) at a target placed on a good length’ (17 m). This can be determined as an area on the field where the bowler intends to pitch the ball to create indecision in the batsman whether to play forwards or back. The anatomical landmarks were marked with the help of coloured tape.

**Data collection**

Filming took place post-season in the practicing area on a turf wicket. Two High Definition Sony video cameras were mounted in coplanar locations, on stationary Manfrotto 117 rigid tripods, to record each delivery for digitizing
purposes. Both cameras were placed with 10 to 150 mm zoom lenses and were mounted at a height of 1.5 m, measured using a plumb-line. Each lens was adjusted to maximize the size of the performer in the viewfinder, thus enabling maximum accuracy (Winter, 1979). They were placed in the same horizontal plane and aligned so that their optical axes intersected orthogonally over the area of performance (Fig. 1). A standard PAL frequency was used (25 Hz) and the shutter speed was set at 1/2000 s to accommodate the rapid movements observable during delivery. Each trial was recorded with SONY HDR- HC3E video recorders loaded with SONY SUPER SG super VHS video cassettes. A 25-point calibration frame (Peak Performance Technologies Inc., Englewood, CO, USA) of known world coordinates was erected approximately 20 m from each camera. As the calibration frame volume was limited to 1.9 ' 1.6 ' 2.2 m (6.7 m³), reconstruction accuracy of real-world coordinates can only be guaranteed within the space delimited by these points (Wood and Marshall, 1986). The field of analysis was modified accordingly to encompass the period between back foot impact and the first foot contact after ball release (follow-through). Assessment of horizontal velocity of the run-up during the pre-delivery stride was achieved using stop watch (Titan Sport AB, India).
Data reduction

A Windows XP-based Dart fish Motion analysis System (Version 4.5.2.0) software package was used to capture data from film. An interfaced Panasonic AG-6500 video playback system increased the sampling rate to 50 fields per second. A user-defined 18-point, 16-segment spatial model was selected and points 1-18 were digitized between back foot impact and the follow-through. Ten additional fields were digitized before back foot impact and 10 fields after follow-through for smoothing purposes.
Ball speed measurement

The investigator used the electronic sensor Platypus ball for the purpose of measuring the ball speed of the bowler.

![Platypus ball](image)

Fig 2  Platypus ball

Selection of Variables

The investigator reviewed the available scientific literature pertaining to bowling in cricket and consulted with faculty members and experts. Considering the importance, feasibility criteria and the availability of instruments for the present study the following variables were selected for this study:
Criterion variable.

a. Bowling performance in cricket.

Bowlers coming under or above the classification of medium fast were considered. The average speed of bowling comes to 130 klm/h.

Experimental variables

a. Speed
b. Force
c. Acceleration
d. Power

The following sub variables were selected in relation to the experimental variables

a) Weight of the body
b) Height of the body
c) Arm length
d) Leg length
e) Hand length
f) Upper body length
g) Lower body length
Fast, medium and slow bowling involves repetitive twisting, extension and rotation in a short period while body tissues and footwear must absorb the large ground reaction forces. It is the speed, and thus the force of the action, that makes the fast bowler stand out as having a higher incidence of injury. The bowling action itself can be divided into three stages: the run-up to back foot impact (BFI), the delivery stride and the release. The run up to the BFI is the movement of the bowler from stance (i.e. a standing position) to the landing of the back foot. The delivery stride is the period between the back foot impact and ball release. The release phase occurs when the ball actually leaves the hand.
and has been delivered to the receiving batter. These actions entail a large variety of biomechanical aspects.

**The run up to back foot impact**

![Fig 4 Back foot impact](image)

The aim of all fast bowlers is to have a well-measured approach, building up to optimum speed about 3 to 4 strides before delivery of the ball (Elliott et al., 1986). The speed at which a fast bowler approaches the wicket influences the velocity of the ball at release (Stockhill & Bartlett, 1993). It also largely determines the alignment of the hips and shoulders at back foot impact and therefore the type of bowling action used (Elliott et al., 1986; Foster et al., 1989; Burnett et al., 1995). It is believed that a too fast run-up makes it difficult for a bowler to convert comfortably to a side-on delivery action. Conversely a too slow
a run-up will reduce the contribution of the linear velocity (i.e. rate at which the body moves in a straight line from one location to another) of the hip relative to the ball (Elliott et al., 1986). It is for this reason that researchers have looked at these biomechanical aspects of the run-up to the BFI. The approach velocity and the speed of the run-up was however found to not contribute to the incidence of abnormal radiological features (Foster et al., 1989). The angle of the back foot and shoulder alignment are thought to be significant in the incidence of abnormal radiological features as they determine which bowling action a bowler uses (i.e. side-on, front-on or mixed action) (Elliott et al., 1986). Bradman (1958) summed up this phase of the delivery by stating that the wind-up is the most important phase in attaining a side-on bowling action as errors at this stage cannot be compensated for later in the movement (Elliott et al., 1986). Back foot alignment indicates the angle at which the foot is placed in reference to the wicket/square leg region. Back foot alignment was not, however, found to be a significant factor relating to the incidence of radiological features in a number of studies (Foster et al., 1989; Elliott et al., 1992; Elliott et al., 1993). Elliott et al. (1986) indicated that positioning of the back foot may influence the angle of the shoulder as the bowler moves into the delivery stride. However, shoulder alignment was not found to be a factor contributing to the incidence of radiological features in 25 studies by Foster et al. (1989) and Elliott et al. (1993). In contrast, Elliott et al. (1992) found shoulder alignment to be significantly higher (more front-on alignment) in those with radiological features than those without. The bowler also experiences a
series of impacts with the surface during the run-up and delivery phases. These forces are transmitted through the bones, cartilage, tendons, ligaments and muscles of the foot, leg, thigh and pelvis to the intervertebral discs and the facet joints of the vertebrae (Nigg, 1983; Elliott et al., 1995). Mason et al. (1989) stated that these forces could be absorbed by the body, but, when combined with a bowling technique that changes the axis of stress to the pars area, these forces could cause bony abnormalities. Foster et al. (1989) explained the situation as follows: if the spine is erect, which is the case in the side-on bowling position, the intervertebral compressive forces developed through impact is more likely to be resisted by the bowler's intervertebral discs.

The delivery stride

![Fig 5 The delivery stride](image)
The delivery stride contains the greatest risk for back injury in fast bowlers because the trunk experiences high degrees of lateral flexion, hyperextension and rotation when ground reaction forces are at their highest levels (Elliott et al., 1986, 1989; 1992; Foster et al., 1989; Mason et al., 1989). The delivery stride can be further broken into separate segments: the stride length, stride alignment and shoulder alignment. The stride length refers to the distance between the back foot impact and front foot impact. It has been suggested that those who approach the bowling crease at too high a velocity have a shorter delivery stride. This may inhibit their ability to master a side-on delivery and thus predispose them to injury. The second important factor in the delivery phase is the stride alignment. It has been recommended that the back foot, the front foot and stumps (wickets) should form a straight line during the delivery stride (Elliott and Foster, 1989; Elliott et al., 1992). Despite this recommendation, Elliott et al. (1992) reported no significant differences among the defined groups of those with no abnormal radiological feature, those with disk degeneration or those with spondylolisthistic features. Shoulder alignment refers to the movement of the shoulders between the back foot impact (BFI) and front foot impact (FFI). This is a stage in the delivery phase that is believed to be of prime importance in predisposing the lumbar spine to injury (Elliott et al., 1986; Foster et al., 1989; Hardcastle et al., 1991; Elliott et al., 1992). For example, a significant difference was noted between the minimum shoulder alignment of those 26 with abnormal radiological features and those without these fractures in a number of studies (Foster et al.,
1989; Elliott et al., 1992). In contrast to the above studies, Elliott et al. (1992) suggested that mean shoulder alignment may not be the predisposing factor in the appearance of abnormal radiological features in the lumbar spine. These authors argued that in bowlers with appropriate lower body orientation, the shoulder orientation would not cause excessive hyperextension of the spine with this rotation of the trunk. It has also been suggested that ground reaction forces during the delivery phase can also lead to radiological features. However, this contention was not supported by the studies of Elliott et al. (1992) or Foster et al. (1989).

The release

Fig 6 The release
The final stage of the bowling action is the release phase. The release phase occurs when the arm extends and the ball is delivered. Finally, a follow through action is taken. When expressed as an absolute value, or a percentage of the standing height, the height of release has been found to be significantly related to the occurrence of stress fractures of the lower lumbar spine. In other words, bowlers who sustained stress fractures tended to deliver the ball from a greater height than bowlers who were not injured (Foster et al., 1989; Elliott et al., 1992). In another study, however, Elliott et al. (1993) found no relationship between heights of ball release to standing height and the incidence of radiological features. The extension of the front knee joint during the release phase is also an important biomechanical aspect of fast bowling. Bowlers flex the knee joints between front foot impact and release to dissipate ground reaction forces (Elliott et al., 1993). It has been suggested that this reduces the height of release and the incidence of radiological features (Foster et al., 1989). This suggestion, however, was not supported by a study of disk degeneration and the young fast bowler in cricket (Elliott et al., 1993).

Design

This is a relationship study designed to find out the importance of kinematic variables such as Speed, Force, Power and Acceleration in the performance of cricket bowling.
Fig VII

Bowling arm angle at the time of delivery

Fig VIII

Non bowling arm angle at the time of delivery
Leading leg inner angle at the time of delivery

Fig IX

Back leg angle at the time of delivery

Fig X
Fig XI

Last stride length

Fig XII

Back leg ankles angle at front foot landing
Front leg ankles angle at front foot landing

Fig XIII

Upper body angle at front foot landing

Fig XIV
Bowling arm angle at front foot landing

Fig XV

Non bowling arm angle at front foot landing

Fig XVI
Fig XVII

Leading leg knee angle at front foot landing

Fig XVIII

Back leg knee angle at front foot landing
Upper body angle at back foot landing

Fig XIX

Bowling arm angle at back foot landing

Fig XX
Fig XXI

Non bowling arm angle at back foot landing

Fig XXII

Leading leg knee angle at back foot landing
Back leg knee angle at back foot landing

Fig XXIII
Speed

Speed is the ability to execute motor action, under given condition, in minimum possible time. In sports field including games the importance of sports factor is enormous. Speed is highly specific ability. In cricket speed is required in every skill pertaining to batting, bowling and fielding. For a bowler while bowling with a ball he has to bowl at a fastest rate of speed to get batsmen out. Speed requires fast and explosive movement hence the importance of speed cannot be under estimated. Speed ability are also very important because certain other abilities depend to a lesser or greater extent on these abilities. Considering the above importance in cricket speed was chosen as a variable.

Force

Force is that which alters or tents to alter a body’s state of rest or of uniform motion in a straight line. All changes in motion are due to some force action, but not all force action result in changes in motion of body acted upon. In cricket a bowler leans backward and forward at the time of delivering the ball to get the complete body force into the ball. Taking into consideration of the above facts force was selected as a variable for this study.

Power

Power is the capacity of an individual to bring into play the maximum muscle contraction at the fastest rate of speed. Of all the conditional abilities
power is one of the most important factors in sports and games. The other conditional abilities and coordination abilities are affected to a lesser or greater extent by power ability. Depending upon the magnitude and type of resistance to be tackled in various sports it needs different levels of speed, endurance, techniques, tactics and other coordinative abilities. This will not be possible if the sports person was lacking in this. Fast bowlers use the power of their shoulders or the wrist to generate more power into the ball at the maximum speed. Due to the above facts power was selected as a variable for this study.

**Acceleration**

Acceleration is the rate of change of velocity. The role of acceleration in the optimal performance for a sportsman is very high. The athlete who runs in a shorter version should accelerate his speed in his every stride to maximize his performance. In cricket while bowling the bowler should attain his maximum acceleration during his run-up is very necessary. This helps the bowler to get the required momentum to deliver the ball at a maximum speed. Considering the above facts acceleration was chosen as a variable for study.

**Collection of Data**

Using standardized Indian equipments kinematic variables will be measured. Anthropometric measurement will be made with the help of measuring tape and weighing machine. Height, total body mass and anthropometric lengths (shoulder finger end, wrist finger end, upper body
lengths and lower body lengths) of the bowler were assessed using the standardized guidelines provided by Martin et al. (1988) and Ross and Marfell-Jones (1991). Items of clothing that interfered with the measurement process were removed before testing to maximize accuracy. Intra-rater reliability measurements were taken at approximately the same time of day with an intervening time interval of 48 h.

**Force**

The force was measured by multiplying the mass of each bowler by his acceleration

\[
F = ma
\]

Where

- \( F \) = Force
- \( M \) = Mass
- \( A \) = Acceleration
- \( M = \frac{W}{g} \)

Where

- \( W \) = weight of the batsmen
- \( g \) = Gravity

**Weight**

The body weight of each bowler was measured in kilograms by using standard weighing machine.
Mass

The mass is each bowler was calculated by dividing the weight of each bowler by gravitational force.

Where \[ m = \frac{w}{g} \]

\[ M = \text{mass} \]
\[ W = \text{weight} \]
\[ G = \text{gravitational force} \ 32.2 \text{ ft} / \text{sec}^2 \]

is constant or \( 9.8 \text{ m/s}^2 \)

Acceleration

Acceleration of the bowler was calculated by dividing the speed of the bowler with the time taken by the bowler to run the distance in between the start of his bowling and the delivery of the ball and using the formula.

\[ \frac{V_f - V_i}{t} \]

That is

\[ V_f - V_i \]

\[ a = \frac{V_f - V_i}{t} \]

where

\[ a = \text{the average acceleration} \]
\[ V_f = \text{final velocity} \]
\[ V_i = \text{initial velocity} \]
\[ t = \text{elapsed time} \]
Power

The power of the bowler was calculated by multiplying the force of the bowler with the final speed of the bowler which is calculated by dividing a small distance just before releasing the ball and the time taken to cover the distance.

\[ P = fV_f \]

Where \( P \) = power

\( F \) = force

\( V_f \) = Final velocity

Speed

Speed of the bowler was measured by measuring the time of running in a fifty meter dash.

Speed = Distance covered / Time taken

That is

\[ \frac{d}{a} = \frac{\text{distance covered}}{\text{time taken}} \]

Where \( d \) = distance covered

\( t \) = time taken
Statistical Analysis

The mode of analysis of data on the selected dependent variables and ball speed among the selected cricket players have been statistically analyzed by using correlation and regression equation. To determine the relationship between the dependent variable and independent variable Pearson product moment correlation was used. The computation of multiple regression was also used. In multiple regression, we are predicting a criterion variable from a set of predictors. Forward selection method of multiple regressions was used in this study to find out the predictor variable that has the highest correlation with the criterion variables is entered into the equation first. The rest of the variables are entered according to the contribution of each predictor. In all cases 0.05 level of significance was fixed to test the hypothesis.