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Kinematic analysis of pitching in baseball

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Abstract
The purpose of the present study was to investigate the relationships between the kinematic analysis and performance of pitchers. Total Two pitchers were selected as a sample: Indian international male pitchers who had represented at international level were selected as a sample on the basis of performance in preceding competition. The age of all the subjects will be ranged above 22 to 26 years. The kinematic variables were wrist angle, elbow angle, shoulder angle at the time of pitching and performance of pitchers. The Kinematic Analysis of pitchers mean, standard deviation and Karl Pearson's product moment coefficient correlation were employed with the help of statistical package of SPSS. The level of significance was set at 0.05. The outcome of the study shows that significant relationship with performance (.772, .992, .922,) of pitchers in all variables.

Keywords: Kinematic, wrist angle, elbow angle, shoulder angle

Introduction
The biomechanics of pitching are studied extensively. The phases of throwing embrace windup, early cocking, late cocking, early acceleration, late acceleration, speed, and follow-through. Pitchers throw a spread of pitches, every of that features a slightly totally different rate, trajectory, movement, hand position, radiocarpal joint position and/or arm angle. These variations are introduced to confuse the batter in varied ways in which, and ultimately aid the defensive team in obtaining the batter or base runners out. To get selection, and so enhance defensive baseball strategy, the pitcher manipulates the grip on the ball at the purpose of unleash. Variations within the grip cause the seams to "catch" the air otherwise, thereby dynamic the flight of the ball, creating it more durable for the batter to hit. The choice of that pitch to use will rely on a good kind of factors together with the kind of hitter, who is being long-faced, whether or not there are any base runners, what percentage outs are created within the play, and also the current score (Peggy A. Houglum, 2016) [5].

Windup
Windup, the setting part of the pitching motion, happens once the individual positions the body specified the glove aspect is facing the target. The aim of the windup is to line a rhythm that establishes a synchronic temporal order of the body elements. At the beginning, the 2 hands are along and close to the body anyplace from the belt to the pinnacle as he takes a step back with the leg contra lateral to the throwing arm. This contra lateral leg is that the stride leg whereas the ipsilateral leg is that the support leg. With the load transfer, the body rotates 90° because the stride leg flexes at the hip and knee that the pelvis rotates towards the throwing shoulder and therefore the body parts pine flexes slightly. The body lands up in order that all segments of the body from the legs to the arms are able to contribute to the ball's propulsion. This part may be aminimally demanding portion of the pitching motion. Speed, energy expenditure, and forces generated are all at low levels (Peggy A. Houglum, 2016) [5].

Cocking
Cocking begins once the hands separate and ends once abduction and most lateral rotation of the shoulder is achieved. Cocking is split into early cocking and late cocking in keeping with the contact of the forward foot on the bottom. In early cocking, the shoulder bone is backward and therefore the arm bone is abducted,

laterally turned, and horizontally extended. The elbow flexes. The stride leg begins to increase the knee; abduct, medially rotate and extend the hip; and Evert and area flex the articulatio talocruralis. The non-throwing shoulder is abducted and its elbow is extending. The body's centre of gravity is down as a result of the support knee and hip are flexing and therefore the hips and pelvis begin to rotate forward. Late cocking begins once the stride foot hits the bottom. At the time of foot contact, each arm are elevated concerning 90° and in line with one another on the plane of the shoulders. Anterior stress on the glenohumeral joint is predominant at this point, with the body ahead of the arm. The deltoid is powerfully active throughout early cocking. Once most shoulder lateral rotation and abduction to a minimum of 90° occur, the static stabilizers of the shoulder, the glenohumeral capsule and ligaments, serve to limit additional motion. Active stabilizers, together with the forward flexors, lateral rotators, the subscapularis, and pectoral, and latissimus dorsi, act as further restraints to regulate motion. Scapular stabilizers like the pectoral and serratus also are active in late cocking. reciprocal-inhibition therapy of the opposite structure muscles, the musculus teres minor, supraspinatus, and infraspinatus, is additionally happening as these muscles try and resist the superior subluxating forces that occur once the trunk is during a forward lean and therefore the shoulder is maximally laterally turned. At the tip these days cocking, the body part spine hyper extends to feature to the shoulder's lateral rotation. The supraspinatus and infraspinatus are notably active in late cocking. By the tip of this section, the shoulder medial rotators are on most stretch, the body is "wound" optimally for the potential energy transfer, and therefore the pelvis leads the shoulders to face the target legs and trunk begins their acceleration for energy transfer to the arm. Right before the tip of this section, the body laterally tilts to the non-throwing arm aspect. Shoulder rotation to the target and lateral trunk motion are expedited by the non-throwing arm's motion from a footing of abduction at the beginning these days cocking to movement and extension at the tip (Peggy A. Houglum, 2016) [5].

Acceleration

Acceleration starts with most shoulder lateral rotation and abduction and ends once the ball leaves the fingers. The movements during this part embody scapular protraction, humeral horizontal flexion and medial rotation, and elbow extension. Simply before ball unleash, the shoulder remains at regarding 90° of abduction. The glenohumeral joint's capsule is wound tight to supply associate elastic force unleash and also the accelerator muscles also are maximally stretched. Throughout this part the speed of the arm has enlarged considerably in an exceedingly comparatively transient amount, starting from nearly 0°/s at the top of cocking to 7500°/s by the top of acceleration, a time of fifty m sec. The anterior serratus muscle and greater pectoral muscle are powerfully active throughout this part because the arm moves forward and also the bone protracts. The subscapularis and latissimus dorsi are getting concentrically because the arm moves into medial rotation throughout acceleration (Peggy A. Houglum, 2016) [5].

Follow-Through

Follow-through happens from the purpose of ball unleash to the completion of the motion once the support leg moves forward and contacts the bottom to prevent forward body motion. it's divided into early and late follow-through in keeping with the purpose of greatest shoulder medial rotation. Early follow-through is completed chop-chop, in but zero.1 s. Trunk rotation and scapular motions occur and are diminished to a varied extent from one vogue to a different, reckoning on the individual thrower. The deltoid is powerfully active throughout early follow-through. The anatomical structure, particularly the lateral rotators, should decelerate the arm when ball unleash and work against the momentum distraction forces occurring at the shoulder. The skeletal muscle is additionally functioning at high levels eccentrically to scale back distraction forces at the elbow. A number of the forces made throughout acceleration are absorbed by the stride leg; it's planted throughout acceleration and flexed knee position absorbs a number of the forces. When the ball is discharged, the throwing arm continues to man ever across the body toward the alternative hip with the bone continued to protract; this cross-body motion helps to attenuate irritation to the anatomical structure since the concomitant scapular motion keeps the coracoacromial arch structures from natural event on the anatomical structure. it's throughout the follow-through that injuries to the posterior shoulder occur. The body should currently dissipate the energy that has been developed to accelerate the ball. This can be one reason it's vital for the body to still move when the ball is discharged. Associate in nursing abrupt stop in arm motion can forest all this energy dissipation and cause these tremendous forces to be absorbed primarily by the shoulder. Flexing the trunk, flexing the support knee, and permitting the arm to continue on its path of movement across the body and to the alternative leg all assist in dissipating this energy and reducing distraction forces on the shoulder (Peggy A. Houglum, 2016) [5].

Statement of the problem

The Problem entitled as "Kinematic Analysis of Pitching in Baseball".

Selection of subjects

Total Two international baseball players were select as a sample for the study. The age of the samples was between 22 to 26 years.

Selection of variables

- Angle of wrist joint at the time of pitching.
- Angle of elbow joint at the time of pitching.
- Angle of shoulder joint at the time of pitching.
- Angle of knee joint at the time of pitching.
- Angle of ankle joint at the time of pitching.
- Horizontal velocity of wrist at the time of pitching
- Horizontal acceleration of wrist at the time of pitching

Criterion measure

The criterion measure for this study was the performance of the pitcher. Total of SIX attempts were given to each subject. The performance of each pitch was judged accurately and performance was recorded.

The selected biomechanical variables such as Angle of wrist joint at the time of releasing, Angle of elbow joint at the time of releasing, Angle of shoulder joint at the time of releasing,

Filming protocol

Digital videography was used to analysis the kinematic variables of male pitcher. Motion capture technique was used in this study. To recorded the video of the pichers, while they performing the pitch digital video camera (50 fps) was used by a professional photographer. After obtaining the recorded video, the video will be analyzed through quintic coaching v-17 software approved by Human kinetics. First video was digitized through quintic coaching v-17 software. After the procedure of digitizing, the video was calibrated. The calibrated video gives us the results through makers, stroboscopic effect technique, stick figures, stopwatch programming, angle manual (horizontal, vertical, draw angles), linear and angular analysis manual etc. with the help of "quintic coaching v-17 software."

Motion capture technique Digital video camera Casio EX-FH 100 (50 fps) was used for videography of pitcher performance. The performance of the subject was recorded with stroboscopic effect from approach to landing. Digital Video camera was placed 7 meter away at the side of pitching plate (lateral axis) of the pitcher.

Administration of the test

Two Indian elite male pitchers who had represented at international level were selected as a sample. All the selected subjects were asked to perform the pitching with their full potential and accurate technique. The pitchers were well directed, informed and prepared for the study. 6 chances were given to every pitcher. They were asked to perform the pitching in the natural way as they actually perform. Ten marks were given for each accurate pitch and zero marks were given for wrong pitch. It was ascertain that subjects possess reasonable level of technique. Players were video graphing with systematic filming method as required. Motion capture technique was used in this study. To recorded the video of the pitchers, while they performing the pitch, digital video camera (50 fps) will be using by a professional photographer. Digital Video camera was placed 7 meter away at the perpendicular to the plane of motion. The height of the camera was 1.49 metres.

Analysis of film and collection of data

Motion capture technique was used in this study. The films were analyzed by used standard "quintic coaching v-17 software" approved by Human kinetics. Videos analysing through strobed photo sequence / stroboscopic effect, stick figure analysis, Quick snap shots with the help of software for analysis of selected variables are presented below:-

Measurement of body angles

Angles were measured through videography technique. The videos of the pitchers were traced with the help of "quintic coaching v-17 software" by using auto tracking markers on the selected body joints of pitcher. Using auto tracking markers in "quintic coaching v-17 software" we diagram the video of pitcher at pitching. In order to receive the complete segmental diagram 'angle finding' option was selected in the software and marks of demanded joints were connected. After completing the marking by joining different highlighted marks on the selected body joints software automatically present the measurements of required angles. Different segments were drawn to find out different angles of the body e.g. wrist angle, angle of elbow joint, angle of shoulder joint.

Statistical procedure

With regard to purpose of the study Karl Pearson's product moment coefficient correlation statistical technique was calculate between selected kinematical variables with performance of male pitchers. In order to check the significance, level of significance was set at 0.05.

Table 1: Relationship between Angle of wrist joint of pitcher with performance

Trials	Variables	Mean	Standard Deviation	Correlation Value (r)
12	Angle of wrist joint	1.56	7.64	.772*
12	Performance	7.50	4.52	

'r'0.05 (10) =.576 *=significant at .05 level of significance

Table & figure 1 shows that the mean value of angle of wrist joint of pitchers was 1.56, whereas the standard deviation (SD) of angle of wrist joint of pitchers was 7.64respectively. At the time of calculation of the relationship between Angle of wrist joint with performance of pitcher the r value was .772. The data does suggest that there is significant relationship between Angle of wrist joint of pitcher with performance.

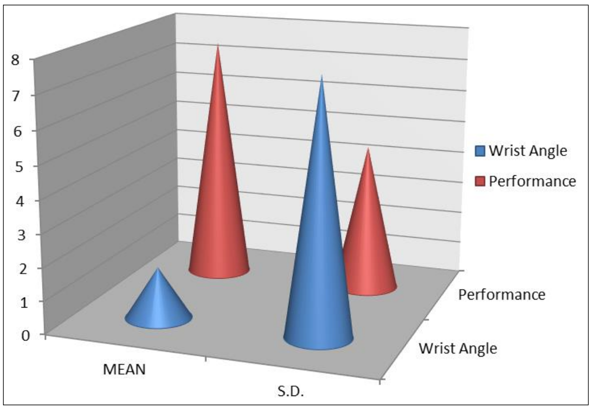

Fig 1: Mean and standard deviation values of pitcher angle of wrist joint and performance

Table 2: Relationship between Angle of elbow joint in pitching with performance

Trials	Variables	Mean	Standard Deviation	Correlation (r) Value
12	Angle of elbow joint	1.60	6.67	.992*
12	Performance	7.50	4.52	

'r'0.05(10) =.576 *=significant at .05 level of significance

Table and figure 2 shows that the mean value of angle of elbow joint of pitchers was 1.60, whereas the standard deviation (SD) of angle of elbow joint of pitchers was 6.67 respectively. At the time of calculation of the relationship between Angle of elbow joint with performance of pitcher the r value was .992. The data does suggest that there is significant relationship between Angle of elbow joint of pitcher with performance.

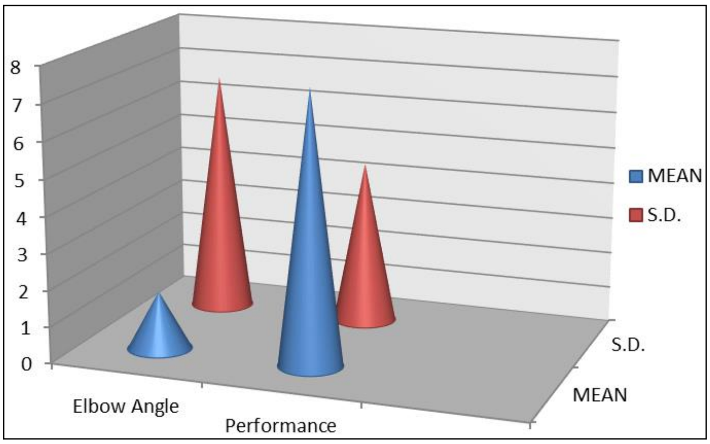

Fig 2: Mean and standard deviation values of pitcher angle of elbow joint and performance.

Table 3: Relationship between Angle of shoulder joint in pitching with performance

Trials	Variables	Mean	Standard Deviation	Correlation (r) Value
12	Angle of shoulder joint	1.41	4.12	.972*
12	Performance	7.50	4.52	

'r'0.05 (10) =.576 *=significant at .05 level of significance

Table and figure 3 shows that the mean value of angle of shoulder joint of pitchers was 1.41, whereas the standard deviation (SD) of angle of shoulder joint of pitchers was 4.12 respectively. At the time of calculation of the relationship between Angle of shoulder joint with performance of pitcher the r value was .972. The data does suggest that there is insignificant relationship between Angle of shoulder joint of pitcher with performance

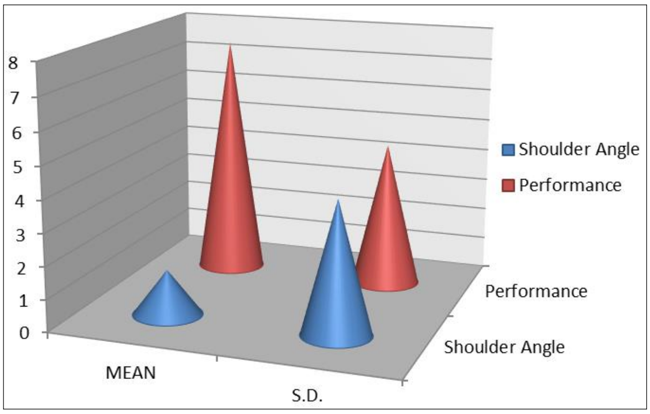

Fig 3: Mean and standard deviation values of pitcher Angle of shoulder joint and performance

Conclusion

Based on the analysis and within the limitations of the study following conclusions were drawn:

1. There was significant relationship between angle of wrist joint and performance of Indian international male pitchers.
2. There was significant relationship between angle of elbow joint and performance of Indian international male pitchers.
3. There was significant relationship between angle of shoulder joint and performance of Indian international male pitchers.

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