Journal of Sports and Games
Volume 1, Issue 2, 2019, PP 8-12
ISSN 2642-8466

Biomechanical Analysis of Overhand Pitching Motion in Professional Baseball Players

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ABSTRACT

The purpose of this research is to analyze pitching motions of professional and college baseball players kinetically and to investigate the differences through the scientific method for the performance of the pitching motion, so that it can suggest and right pitching motions and provide the effective pitching motions to improve athletic performance and to prevent injury. It is considered to be effective that players should shorten the required time by minimizing their motions and securing for fast and correct pitching. Important to minimize the right and left motions when those are divided into a section of accumulating quantity of motion and generating power to secure stable body effectively. Thought that at the moment of pitching motion, smoothly move when the supporting leg should bend the knee and ankle joints using the gastrocnemius and the leg pushing ahead should control the body rapidly moving to the direction of progress in the lower limbs using the straight muscle of thigh and the anterior tibial muscle and should maintain the bent knee joint by biceps femor is to the hilt. In addition, the most advisable pitching motion is judged to pitch a ball by maximizing the turning force gained from the proximal segment in the distal segment through flexure and extension of the shoulder, elbow and carpal joints to effectively use the strong turning force based on the stable center of gravity.

Keywords: *Biomechanical, Pitching, Professional baseball players*

CASE PRESENTATION

The purpose of this study was to perform kinematic analysis, using 3D imaging, and kinetic analysis, using EMG, to study different events and intervals during pitching in 2 currently registered professional baseball players (age: 32.5 years, body weight: 95kg, carrier: 23.5 years) with at least 10 victories in the last 3 years, and in 2 amateur university players (age: 22 years, body weight: 80.5kg, carrier: 14.5 years). We derived the following conclusions.

P 1: wind-up, P 2: stride, P 3: arm coking, P 4: arm acceleration, P 5: arm deceleration, E 1: Preparing to pitch, E 2: Peak knee height for the front leg (weight-bearing leg during pitching), E 3: Contact of the front leg with the ground, E 4: Peak external rotation of the throwing shoulder, E 5: Release of ball from the hand, E 6: Peak internal rotation of the throwing shoulder.

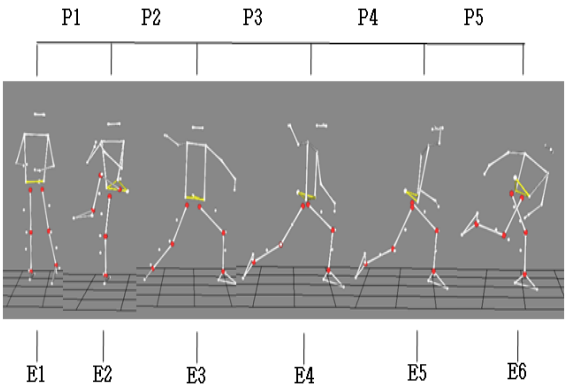


Figure1. *Intervals and events during pitching*

DISCUSION/CONCLUSION

When considering the time required for a pitching motion in baseball, during P1, which is

the interval from rest before pitching to the development of angular momentum, the shortest possible time is desired to effectively balance the center of mass (CoM) while minimizing unnecessary movements.

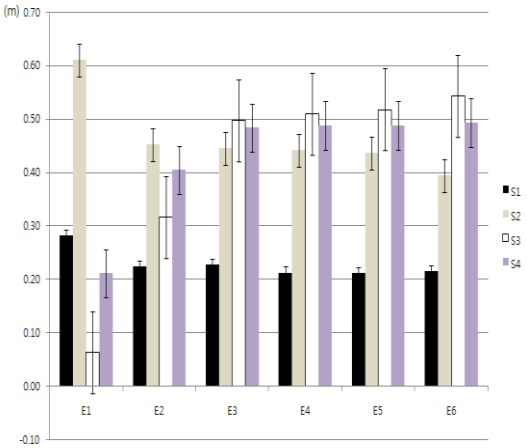
In P2, the pitcher should move rapidly to bring their front log into contact with the ground and achieve stability; this propels the upper body forward, which then needs to be rotated in P3 to launch the ball (1-3)

Table1.*Time required for each interval (Unit: sec)*

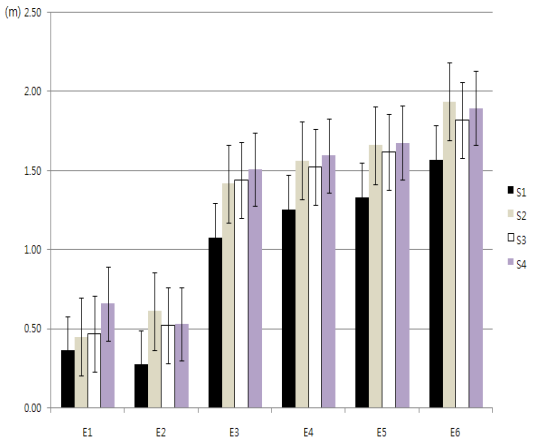
Athletics	Subjects	P1	P2	P3	P4	P5	Total
Professional	S1	0.76±0.12	0.80±0.03	0.10±0.02	0.05±00.01	0.28±0.04	1.99±0.08
	S2	0.71±0.05	0.64±00.02	0.07±0.00	0.05±0.01	0.27±0.02	1.74±0.05
	Mean	0.73±0.04	0.72±0.11	0.08±0.02	0.05±0.00	0.28±0.01	1.86±0.18
Amateur	S3	1.10±0.24	0.93±0.05	0.04±0.01	0.05±0.00	0.21±0.03	2.32±0..23
	S4	0.78±0.02	1.49±0.04	0.04±0.00	0.05V.01	0.24±0.01	2.59±0.05
	Mean	0.94±0.23	1.21±0.40	0.04±0.00	0.05±0.00	0.22±0.02	2.45±0.19

The data was presented Mean±SD

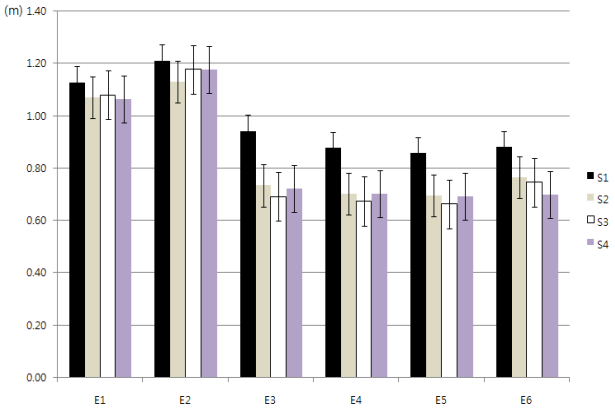
During the change in the position of the CoM, the pitcher should step in the direction of the front leg with an appropriate a stride length to effectively acquire a solid base of support and perform a stable pitching motion; it is important to convert the angular momentum stored in each joint into powerful movement in the forward direction(4-5).



a) Changes in left/right (X axis) position of the CoM



b) Changes in forward/backward (Y axis) position of the CoM

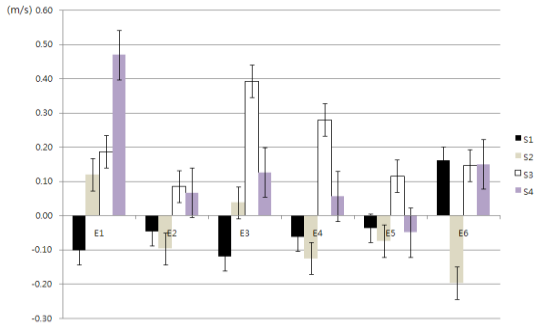


c) Changes in up/down (Z axis) position of the CoM

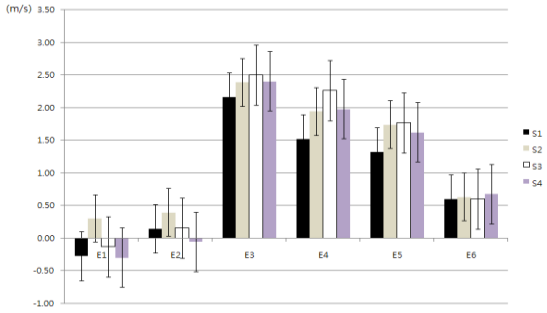
Figure2. *Change in position of the CoM*

During the change in velocity of the CoM, in order to throw an accurate fastball, it is important for the pitcher to select an appropriate position and to rapidly shift their CoM forwards and minimize lateral movement, while forming a straight line between the center of back foot supporting the body, the forward-moving foot, and the tip of

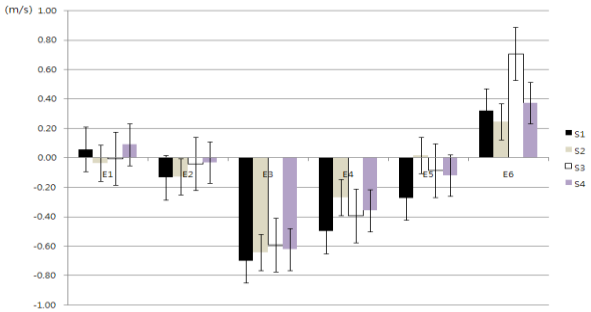
home plate. In addition, the pitcher needs to control their forward speed in order to rotate the upper body around the vertical axis passing through a stable CoM (6-7)



a) Changes in left/right velocity (X axis) of the CoM

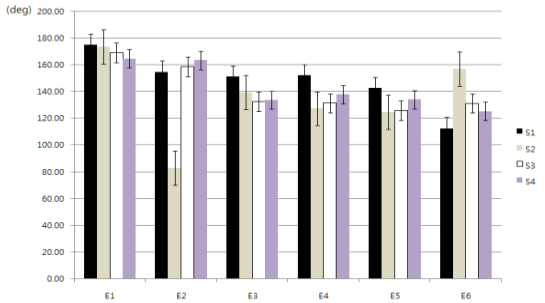


b) Changes in forward/backward (Y axis) velocity of the CoM

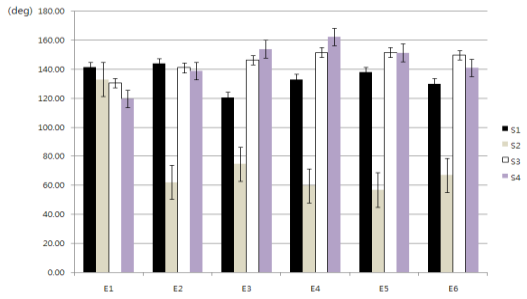


c) Changes in up/down (Z axis) of the CoM

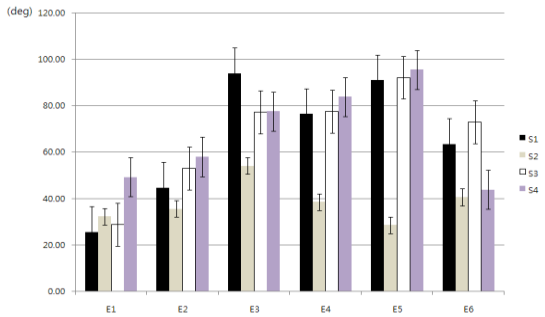
Figure3. Change in velocity of the CoM



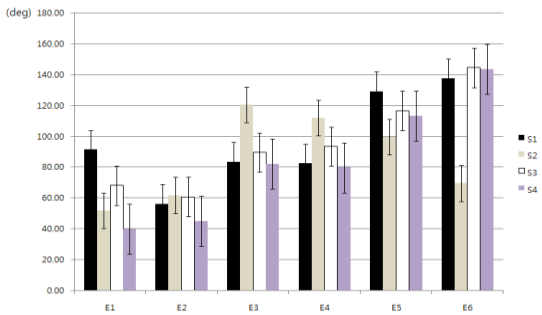
a) Changes in knee joint angle



b) Changes in hip joint angle



c) Changes in shoulder joint angle



d) Changes in elbow joint angle

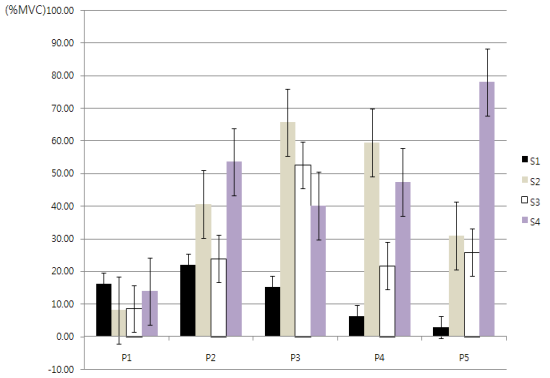
Figure4. *Change in angle for each joint*

During the change in angle of the body segments, it is most effective to achieve a powerful forward thrust by knee extension, to rotate the upper body, and to enhance the force of upper body

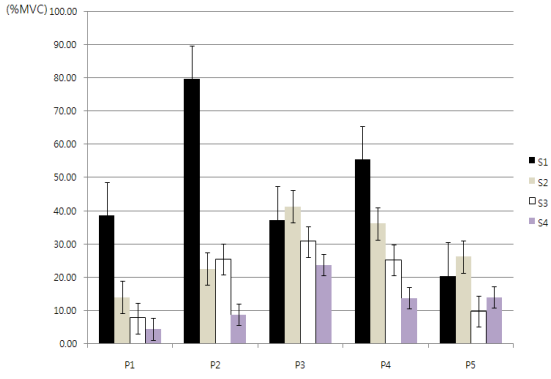
rotation through hip flexion and extension.

The non-throwing shoulder should start in a position of flexion lateral to the front leg to increase the rotational force, while the throwing shoulder should be flexed to transfer the kinetic energy starting in the proximal segments to the distal segments, and increase the efficiency of the pitching motion.

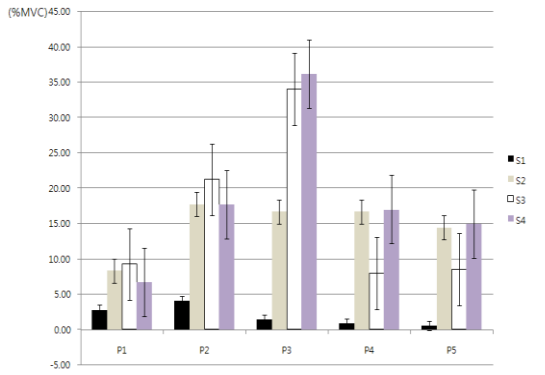
In the process of transferring kinetic energy from the proximal to the distal segments, the elbow should be flexed and extended to increase the kinetic energy, and the wrist should be extended before releasing the ball, in order to efficiently utilize the kinetic energy produced by maximal external rotation of the whole arm before releasing the ball (8-10). In EMG, muscle activity showed that the gastrocnemius muscle of the supporting leg should be used to flex the knee and ankle, in order to form a vertical axis. Rectus femoris and tibialis anterior of the forward-moving leg should be used to control the rapid forward movement of the body, and biceps femoris should be used to maintain flexion of the knee as far as possible, enhancing rotation of the upper body (11-12)



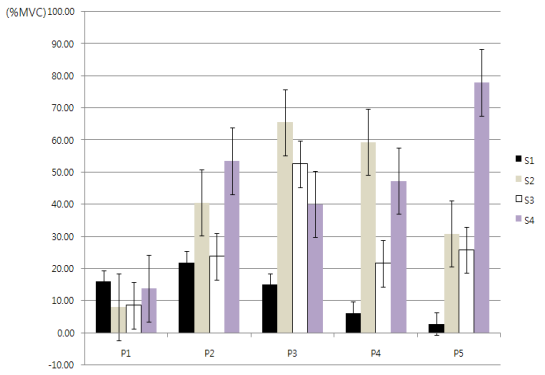
a) Changes in rectus femoris muscle activity



b) Changes in biceps femoris muscle activity



c) Changes in anterior tibialis muscle activity



d) Changes in gastrocnemius muscle activity

Figure5. *Muscle activity*

Combining the above results, we found that, for fast, accurate pitching, it is efficient to minimize movement and maintain balance in order to complete the pitching movement in a short time. In order to efficiently ensure stability of the body, when the movement is divided into an interval for storing momentum and an interval for releasing the energy, it is important to minimize lateral movement. During pitching, the gastrocnemius muscle of the supporting leg is used to flex the knee and ankle, and the rectus femoris and tibialis anterior muscles of the front leg are used to control the rapid forward movement of the body and the biceps femoris muscle should be used to maintain knee flexion as far as possible, in order to enable fluid movement of the upper body.

In order to effectively utilize the powerful rotational force based on a stable CoM, flexion and extension of the shoulder, elbow, and knee should be used to maximize the transfer of rotational energy from the proximal segments to the distal segments during pitching.

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Citation: *Yun-A Shin, Won-Ho Choi, Young-Seok Kang, "Biomechanical Analysis of Overhand Pitching Motion in Professional Baseball Players", Journal of Sports and Games, 1(2), 2019, pp. 8-12.*