PITCHING ANALYSIS OF BODY VARIABLES ACCORDING TO BALL VELOCITY IN AMATEUR BASEBALL PITCHERS USING GYRO SENSOR.

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Abstract- In baseball, pitching with maximum ball velocity is an important factor for a pitcher's success. Some studies have used the inertial sensors in a manner to compensate for these limitations of the motion capture system for obtaining kinematic data. For this reason, inertial sensors (gyro sensor) were also used in this study to analyze body variables during pitching performance. Thus, the purpose of this study was to examine the correlation of ball velocity with body variables in eight amateur baseball pitchers. In this study, they performed 10 to 15 maximal fastball pitch trials. Pitching velocity was measured by speed gun. The wearable gyro sensor was used to investigate the body variables (horizontal abduction and abduction of shoulder, trunk rotation angle (anterior and posterior), trunk rotation angular velocity, food direction, stride length) during the pitching performance. The mean and standard deviation data from the eight amateur pitchers was used for data analysis. We calculated a Pearson correlation coefficient to determine the associations between ball velocity and body variables. According to result, ball velocity significantly correlated with the horizontal abduction and abduction of shoulder at arm cocking, torso angular velocity and stride length ($p<0.05$). When the external rotation is greater, stronger shoulder contraction may occur due to the action of stored elastic energy, the myotatic reflex, and a greater rate of force production during pre-stretched and contracting muscles during arm acceleration phase. For stride length, it is regarded a not only critical kinematic factor for determine the timing of kinetic chain events but also transitioning energy to the pitching arm from lower extremity. As increased trunk rotation angular velocity, levels of trunks action develop more advanced and led to increases in energy transfer to the pitching arm. Thus, these body variables should be considered to increase the ball velocity, which is an important ability of the baseball pitcher in training and rehabilitation.

Keywords- Gyro, Baseball, Pitcher, Ball velocity, Kinematics, Biomechanics

I. INTRODUCTION

In Motion capture system with video cameras has long been used to examine the kinematic analysis of the baseball pitching motion in an indoor laboratory [1][2][3]. However, such systems are used indoors in controlled environment, and the capture range must be taken into consideration [4]. Some studies have used the inertial sensors in a manner to compensate for these limitations of the motion capture system for obtaining kinematic data. Wearable motion sensor suits have been considered as a cheap alternative to optical motion analysis systems for obtaining kinematic data [5]. The optical motion analysis system has long been acknowledged to provide the precise human kinematic data, and the data from wearable motion sensor suits have been proven to be highly correlated with it ($r = 0.9$) [6]. For this reason, inertial sensors (gyro sensor) were also used in this study to analyze body variables during pitching performance.

Baseball pitching with maximum ball velocity is an important factor for a pitcher's capacity. Accordingly, many studies have examined relationships between ball velocity and body variables in baseball pitchers. These studies provide the factors that affect pitcher's ball velocity such as body height, arm length, kinematic and kinetic parameter of body. Appropriate pitching mechanics, in particular, are important in preventing injuries and enhancing pitching performance [7].

Knowledge of kinematic factors the correlate with velocity baseball pitchers could provide therapist and pitching coaches with areas on which to focus in training and pitcher development [8]. However, few studies have examined the correlation of ball velocity with body variables. Consequently, the purpose of this study was to investigate the correlation between body variables and pitching velocity using gyro sensor in amateur baseball pitchers and to compare the results with previous studies.

II. MATERIALS AND METHODS

A. Participants

Eight amateur baseball pitchers agreed and participated in the study. Pitchers had a mean age of 18.38±0.52years, height of 182.22±2.59 and mass of 79.88±6.31kg [Table 1].

Table 1. General characteristics (n=8)

characteristic	Male
Age(years)	18.38±0.52
Height(cm)	182.22±2.59
Mass(kg)	79.88±6.31



Figure 1. MVN, Xsens technologies B.V., Enschede, the Netherlands

B. Procedures

While they perform fastball pitching, their body variables and ball velocity were measured by wearable gyro sensor (MVN, Xsens technologies B.V., Enschede, the Nether- lands) and speed gun. Body variables included range of motion of shoulder (horizontal abduction and abduction) at arm cocking, trunk rotation angular velocity, trunk rotation angle range (posterior), trunk rotation angle range (anterior), foot direction and stride length. Body variables refer to the following; Trunk rotation angle range (posterior) is the angle at which the trunk rotates to backward during wind up phase, trunk rotation angle range (anterior) is the angle at which the trunk rotates forward from windup to ball release phase, foot direction represents angle between line connecting heel and toe and sagittal axis of heel. Pitchers were required from 10 to 15 maximal fastball pitching. One hundred fifteen pitching data were collected from them.

C. Data analysis

Means and standard deviation of all data was analyzed. Pearson correlation coefficients were used to examine the correlation velocity and body variables. Significance levels were set at $p<0.05$. All data analyses were performed using SPSS statistical software (version 22.0; IBM Corp, Armonk, NY).

III. RESULTS

The Correlation of body variables with ball velocity is shown in Table 1. Mean and standard deviation values of ball velocity were 28.48±4.27m/s. According to result, ball velocity significantly correlated with the horizontal abduction and abduction of shoulder, trunk rotation angular velocity, stride length ($p<0.05$). However, no significant correlations were observed in trunk rotation angle (anterior and posterior), foot direction ($p>0.05$).

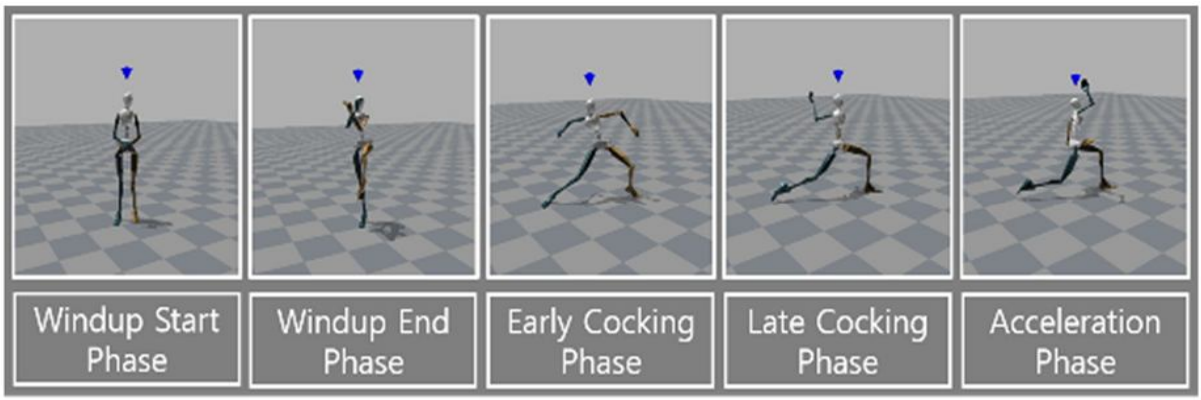


Figure 2. The phases of the pitching motion

TABLE 1. CORRELATION OF BODY VARIABLES WITH BALL VELOCITY

Variable	Coefficient
Shoulder horizontal abduction (˚)	0.524*
Shoulder abduction (˚)	0.343*
Trunk rotation angle (posterior) (˚)	0.142
Trunk rotation angle (anterior) (˚)	- 0.142
Trunk rotation angular velocity (˚/s)	0.719*
Food direction (˚)	- 0.031
Stride length (% height)	0.684*

*** Significant difference ($p<0.05$).**

DISCUSSION

This study investigated the correlation between ball velocity and body variables in amateur baseball pitchers. Ball velocity was affected by horizontal abduction and abduction of shoulder, trunk rotation angular velocity and stride length.

Greater shoulder horizontal abduction during pitching motion has effective pre-stretch, stored elastic energy and tendons may be utilized during arm cocking and arm acceleration phase of pitch [9]. Similarly, other studies have reported a significant correlation between ball speed and external rotation of the shoulder [10]. They found that the high velocity group had greater shoulder external rotation in the arm-cocking phase than the low velocity group. It is reported that when the external rotation is greater, stronger shoulder contraction may occur due to the action of stored

elastic energy, the myotatic reflex, and a greater rate of force production during pre-stretched and contracting muscles during arm acceleration phase. Therefore, in our study, a significant correlation between the ball velocity and the shoulder range of motion (horizontal abduction, abduction) is considered to be due to the principle of this mechanism. Also, trunk rotation angular velocity is important for ball velocity. As increased trunk rotation angular velocity, levels of trunks action develop more advanced and led to increases in energy transfer to the pitching arm [11]. For stride length, it is regarded a not only critical kinematic factor for determine the timing of kinetic chain events but also transitioning energy to the pitching arm from lower extremity [12]. Terrance et al also reported that each increase in stride length by 10% of the subject's height was associated with a 1.9±0.4 mph increase in velocity. As a result, pitching coaches should focus on stride length to increase the ball velocity of the pitcher [8]. There are some limitations to the study. Since the number of subjects in our study is small, it is difficult to generalize the results of the study.

And research was done only on amateur pitchers. If professional baseball pitchers were the subjects of the study, they might have produced a completely different result. Therefore, future study will need to study the pitching kinematic of professional baseball pitchers using a gyro sensor. Furthermore, clarifying the body variables that change with the injury mechanism will be of great help to pitchers and coaches. In conclusion, horizontal abduction and abduction of shoulder, trunk rotation angular velocity and stride length should be considered to increase the ball velocity, which is an important ability of the baseball pitcher in training and rehabilitation.

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REFERENCES

[1] S. Oyama, “Baseball pitching kinematics, joint loads, and injury prevention”, Journal of sport and health science, vol. 1, pp.80-91. June 2012.

[2] Y. Shih, C. S. HO and T. Y. Shiang, “Measuring kinematic change of the foot using a gyro sensor during intense running”, Journal of sports sciences, vol. 32, no. 6, pp. 550-556, Oct. 2013.

[3] Y. Yamada, D. Yamashita, S. Yamamoto, T. Matsui, K. Seo, Y. Azuma, Y. Kida, T. Morihara and M. Kimura, “Whole-body and segmental muscle volume are associated with ball velocity in high school baseball pitchers”, Journal of sports medicine, vol.4 pp.89-95, April 2013.

[4] S. Tadano, R. Takeda and H. Miyagawa, “Three dimensional gait analysis using wearable acceleration and gyro sensors based on quaternion calculations”, Sensors, vol. 13, no. 7, pp.9321-9343, July 2013.

[5] R. Mayagoitia, A. Nene and P. Veltink, “Accelerometer and rate gyroscope measurement of kinematics: An inexpensive alternative to optical motion analysis systems”, Journal of Biomechanics, vol. 35, no. 4, pp. 537–542. 2002.

[6] T. Liu, Y. Inoue and K. Shibata. “Development of a wearable sensor system for quantitative gait analysis”, Measurement, vol. 42, no. 7, pp. 978–988, 2009.

[7] S. Dun, G. S. Fleisig, J. Loftice, D. Kingsley and J. R. Andrews., “The relationship between age and baseball pitching kinematics in professional baseball pitchers”, Journal of biomechanics, vol.40, no. 2, pp.265-270, Jan 2007.

[8] T. Sgroi, P. N. Chalmers, A. J. Riff, M. Lesmiak, E. T. Sayegh, M. A. Wimmer, N. N. Verma, B. J. Cole and A. A. Romeo. “Predictors of throwing velocity in youth and adolescent pitchers”, Journal of shoulder and elbow surgery, vol. 24, no. 9, pp.1339-1345, 2015.

[9] R. Escamilla, G. Fleisig, S. Barrentine, J. Andrews and C. Moorman, “Kinematic and kinetic comparison between American and Korean professional baseball pitchers”, Sports biomechanics vol. 1, no. 2, pp.213-228, 2002.

[10] Tomoyuki matsuo, Rafael F. Escamilla, Glenn S. Fleisig, Steven W. Barrentine and James R. Andrews, “Comparison of kinematic and temporal parameters between different pitch velocity groups”, Journal of applied biomechanics, vol. 17, no. 1, pp.1-13, Feb. 2001.

[11] D. F. Stodden, S. J. Langendorfer, G. S. Fleisig and J. R. Andrews, “Kinematic constraints associated with the acquisition of overarm throwing part 1: step and trunk actions”, Research quarterly for exercise and sport, vol. 77, no.4, pp.417-427, Dec. 2006.

[12] D. K. Ramsey and R. L. Crotin, “Effect of stride length on overarm throwing delivery: part 2: An angular momentum response”, Human movement science, vol. 46, pp.30-38, 2016.

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