Ball speed and spin rate during repetitive pitching by baseball novices

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Published online: July 31, 2021

(Accepted for publication July 15, 2021)

DOI:10.7752/jpes.2021.s3265

Abstract:

Problem Statement: Many studies have examined changes in pitching speed and limitations in the number of pitches during repeated pitching motions by subjects with baseball experience. However, findings during repeated pitching by subjects with little baseball experience have not been reported. **Purpose:** This study aimed to clarify the transition of the speed and the spin rate of a ball thrown repeatedly by an unskilled subject.

Materials and Methods: A healthy male subject threw a ball repeatedly for a total of 100 throws (5 sets at 20 balls/set), and changes in ball speed and spin rate were examined. Ball speed and spin rate were calculated by digitizing eight analysis points on the ball for five frames after ball release. **Results and Discussion:** Results showed that ball speed was significantly lower in the second set than the first set. However, the ball spin rate did not change during the repetitive throwing. When the relative speed to the maximum ball speed was compared with that of baseball players, it was found that not only did the ball speed decrease earlier than that of baseball pitchers during repetitive pitching, but it did not stabilize even during the first set when the effect of fatigue was less. When the coefficient of variation of ball speed within a set was compared with that of male baseball players from adolescents to adults, unskilled players showed the same degree of stability as the adolescent boys, suggesting that training experience may contribute to ball speed stability. When the relationship between ball speed and spin rate was compared with that of baseball players, it became clear that unskilled players had less ball spin to ball speed, suggesting the need to compare pitching motions, including finger movements. **Conclusions:** These results suggest that it is crucial for unskilled players to throw fewer pitches than experienced players during games and to receive training in order to achieve a high pitching speed.

Key Words: pitch count, fatigue, speed training, maximum effort, repetition training

Introduction

Pitching motion in baseball is a powerful dynamic movement that requires coordination of body segments and precisely timed muscle force exertion (i.e., with proper mechanics). Throwing a fastball requires a strong dynamic exertion of these muscles at the right time. In the case of a baseball pitcher, maintaining these elements over a large number of pitches is key to success throughout the game. Repetitive pitching motions can lead to shoulder and elbow injuries due to pitching overload (Chou et al., 2015; Dugas et al., 2012). Muscle fatigue that occurs due to pitching overload can alter pitching mechanics (Chalmers et al., 2017; Chou et al., 2015; Erickson et al., 2016; Escamilla et al., 2007; Hirayama et al., 2008, 2009, 2010; Mullaney et al., 2005; Murray et al., 2001; Okoroha et al., 2018), as well as affect joint flexibility after pitching (Yoshimoto et al., 2020). These issues have suggested that there should be a limit on the number of pitches a pitcher can throw in a game or a season to prevent pitching injury due to fatigue (Lyman et al., 2001, 2002; Lyman & Fleisig, 2005). For this reason, Major League Baseball has implemented guidelines to limit the number of pitches by a pitcher (Major League Baseball Advisory Committee, 2015).

Other studies have reported a decrease in pitching speed during repeated pitching sessions (Maeda & Shirai, 2008; Morimoto & Miyanishi, 2008). Morimoto and Miyanishi (2008) examined the number of pitches to the inflection point at which the pitching speed began to decrease in college baseball players throwing 100 straight pitches at 20-second intervals. They reported that the decrease in pitching speed became pronounced between 40 and 70 pitches. In the case of repetitive pitching in training to increase pitching speed, the principle of overload requires that the training load be applied to the body by throwing a certain amount of pitches, while the principle of specificity requires that training be conducted within the range where high pitching speed can be maintained. These guidelines are expected to provide practical and fundamental knowledge in the training of pitchers.

In the previous studies, skilled players with a certain level of baseball experience were used as participants. Clarifying whether the pitching speed of unskilled players can be maintained as well as that of skilled players, which examines whether training experience contributes to the maintenance of pitching speed. And determining a safe number of pitches for unskilled players would provide basic knowledge for more people to become familiar with baseball safely.

The trajectory of the ball is also expected to change with increased pitches, and the spin of the ball affects this process. Maeda and Shirai (2008) reported that when college baseball pitchers threw repetitively, their throwing speed decreased, but the ball spin rate did not decrease. However, it is not clear whether it is possible to give spin to the ball in unskilled pitchers even when they are fatigued.

The purpose of this study was to clarify the transition of ball speed and spin rate when an unskilled subject throws repeated pitches and to discuss the appropriate number of repetitions for a beginner to pitch at a high ball speed.

Material & methods

Subjects

In this study, the subject had no experience in baseball, but was sufficiently active to keep throwing 100 pitches at full power safely and with full effort (Subject A; height, 182 cm; body mass, 68 kg; age, 33 years). The subject had experienced baseball in school physical education, but had not played in other situations. The subject participated in regular training three times a week (2 hrs each) and participated in track and field competitions. Therefore, we can assume that the subject is accustomed to regular high-intensity exercise. The subjects were informed in advance about the purpose, contents, and risks of this study, and their written consent to participate in the study was obtained. This study was approved by the Research Ethics Committee of the university to which the author belongs.

Experimental test and setup

To exclude the effect of wind, the experimental test was conducted indoors, and a straight ball (four-seam fastball) was thrown with maximum effort toward the "home base" at 18.44 m away. Subject A threw from a set position. To become accustomed to throwing with a straight grip, we had the participants warm-up, including a session of catch-ball with an experienced baseball player. The ball used was a BQNSPD from ASICS Corporation (Japan).

A total of 100 pitches were thrown in 5 sets of 20 pitches. The subject was asked to throw 20 balls at intervals of 10 to 20 seconds. There was a rest period of 6 min between sets. To assist the subject, we placed markers in the strike zone, considering that the subject was unskilled in baseball. In this study, the strike zone was defined as the space on the home plate where the upper limit is the horizontal line drawn between the upper part of the batter's shoulder and the upper part of his uniform pants, and the lower limit is the line below his kneecap (Lepperd, 2019). The average height of a batter in his fourth year of college (Matsumoto and Kunii 1999) was used as a guide for the strike zone, assuming a batter of 171 cm.

Data collection

Figure 1 shows the experimental setup for this study. To calculate the ball's three-dimensional coordinates, two high-speed cameras (DMC-FZ-200, Panasonic) were installed at the height of 1.5 m at 10 m behind the pitcher and at the height of 1.5 m at 10 m to the right of the pitcher. The ball was captured at a shooting speed of 240 frames per second. The two cameras were synchronized so that an LED-synchronizer (PH-145, DKH) was captured by the cameras. A total of 12 control points were photographed as follows: 2 points every 1 m in the left-right direction, 3 points every 1 m in the front-back direction, and 2 points in the vertical direction. This study's coordinate system was the y-axis for the throwing direction, the z-axis for the vertically upward direction, and the x-axis for the direction toward the third base perpendicular to the y- and z-axes in the left-right direction of the subject.

Figure 1. Experimental setup

Data analysis and calculation items

A total of eight points (the center of the ball, two points adjacent to the center of the ball, and five arbitrary points on the edge of the ball) were manually digitized using a motion analysis system (Frame-DIAS V, DKH) from the obtained images of five frames after the ball left the hand (Fig. 2). The three-dimensional coordinates of the analyzed points were calculated by the DLT method using numerical analysis software (MATLAB R2019, The Math Works). The average error in calculating the three-dimensional coordinates was 0.004 m in the X-axis direction, 0.004 m in the Y-axis direction, and 0.004 m in the Z-axis direction.

Figure 2. Eight ball analysis points

The positional coordinates of each coordinate at the time of ball release were time-differentiated. The average values of the five frames after the release were used as variables for both ball speed and spin rate. The composite velocity of the x-, y-, and z-direction components was calculated as the ball velocity. The ball spin rate was calculated based on a previous study method (Jinji and Sakurai 2006). The mean value and standard deviation of the relative ball speed to the maximum ball speed were calculated for each set using the same method as Morimoto and Miyanishi (2008).

Statistical analysis

One-way analysis of variance was used for the differences in each parameter related to the ball speed and the ball spin rate, and multiple comparison tests using the Tukey-Kramer method were performed post-tests. The level of significance level was set to less than 5%.

Results

Figure 3 shows the ball speed and the spin rate. The analysis of variance showed that there was a significant difference in ball speed between the first set and the later sets, but no significant difference in the ball spin rate was observed.

Figure 4 shows the relative ball speed to the maximum ball speed. The relative ball speed was about 90% in the first set and remained at about 75% from the second set onward.

Figure 4. Results of ball speed and ball spin rate for each set

Figure 3 Relative ball speed in each set

Discussion

Figure 3 shows the change in ball speed correlated to the number of pitches (20 pitches per set). As a result of the analysis of variance, a significant difference in ball speed was observed between the first set and all later sets. This indicates that the ball speed of the subjects of this study decreased significantly after about 20 pitches. This result was not consistent with previous studies reported on baseball players (Chou et al., 2015; Erickson et al., 2016; Escamilla et al., 2007; Hirayama et al., 2009; Maeda & Shirai, 2008; Morimoto & Miyanishi, 2008; Mullaney et al., 2005; Murray et al., 2001; Okoroha et al., 2018; Whiteside et al., 2016), which reported that ball speed did not decrease until after at least 40-59 pitches.

The subject decreased his ball speed after the first set, and the range of the decrease was also larger than that of baseball players. The subject's relative ball speed in this study (Fig. 4) was about 90% in the first set and about 75% in the second set and later. However, in the study by Morimoto and Miyanishi (2008), which calculated the relative speed using the same method as this study, the relative speed of the subject was greater than 95% even at the point where the speed decreased the most, around the 100th pitch. The decrease in speed was within a few percent. In contrast, the average relative speed of the subject in this study was about 90% in the first set, indicating a large decrease in throwing speed and an inability to stabilize a high speed even in the first set when they were less fatigued.

The variation of ball speed within a set was compared with previous studies that reported ball speed and standard deviation when a straight ball was thrown (Table 1). All subjects in the previous studies were pitchers. The standard deviation of the pitching speed in the previous study set was 6.1 to 14.4% in youth and adolescent subjects, while it was generally 3-5% in college and professional athletes. The coefficient of variation of ball speed within the present study set was 6.9-9.1%, which is roughly the same as that of pitchers in the youth and adolescent age groups. In the case of unskilled pitchers, not only did the speed of the ball decrease during repetitive pitching, but it was also shown to be unstable. This may be related to the amount of training experience. It was not clear whether this phenomenon was due to physical or technical factors.

Table 1. Comparison of coefficients of variation of ball speed for straight balls in this study and previous studies

	Participants	CV(%)
This study	Adult	6.9 - 9.1
Jinji et al (2006)	Collegiate	5.0
Escamilla et al (2007)	Collegiate	3.3-5.2
Jinji et al (2008)	Youth	10.9
	Collegiate	5.0
Dun et al (2008)	Youth	14.4
Nagami et al (2011)	Collegiate	3.2
	Professional	3.2
Chou et al (2015)	Adolescent	6.1
Erickson et al (2016)	Youth	6.8 - 8.5
Whiteside et al (2016)	Collegiate	5.1

It has been reported that the ball speed of baseball pitchers decreases during repetitive pitching, but the spin rate does not decrease (Maeda and Shirai, 2008). In the present study, the ball spin rate did not decrease during repetitive pitching, indicating that the ball spin rate may be maintained during repetitive pitching even in unskilled players. For example, (Jinji et al., 2008) reported that the ball spin rate of youth baseball players aged 11 to 15 years was 19.6 ± 2.6 rps, and that of college baseball players was 31.9 ± 2.6 rps. The spin rate of the subjects in this study was lower than that of the experienced players. A significant positive correlation has been reported between ball speed and the spin rate (Jinji et al., 2008; Nagami et al., 2011). However, when the ball speed of the youth players in this previous study was compared with that of the subject in this study, the ball speed of the youth players was 25.6 ± 0.4 m/s and the subject in this study achieved the same or higher ball speed. In other words, the subject of this study had less skill in applying spin rate to the ball than baseball players. Matsuo et al. (2018) pointed out that the fingers need to apply a strong force to the ball at the time of release and that this sometimes occurs, especially when inexperienced pitchers are tired. In this study, we did not examine the mechanism of the pitching motion, so it was not clear whether the finger motion caused the difference in the number of spin rates during pitching. However, it is assumed that the subjects in this study had less pitching skills than youth pitchers. In the future, analysis of the pitching motion, including finger movements, of subjects including beginners will contribute to the elucidation of pitching techniques. In addition, since there was only one subject in this study, it is necessary to increase the number of subjects and examine their pitching performance.

Conclusions

In this study, one unskilled subject was asked to perform 100 repetitive throws with full force. As a result, the ball speed showed a large variation in the throwing speed with the ball speed high at the beginning and the speed decreasing significantly during the repetitive throwing. In other words, compared to baseball players, unskilled players are not able to maintain their throwing speed and may throw as few as 20 balls to achieve a high throwing speed. In addition, compared to baseball players, the ball spin rate in this case is lower than the corresponding throwing speed, suggesting that the player may not be able to throw the ball so that the fingers rotate it. When playing baseball, it is desirable to limit the number of pitches practiced to a small number for inexperienced players and assume that pitchers will change early.

Conflicts of interest - There is no conflict of interest.

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