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The relationship between finger strength and spin rate of curve balls thrown by NCAA Division I baseball pitchers

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Abstract

The purpose of this study is to investigate the relationship between finger strength and the spin rate of a curve ball by NCAA Division I baseball players. Fifteen NCAA Division I baseball players, (age 19.4 ± 1.18 years, height 183.56 ± 5.61 cm, weight 83.90 kg ± 8.41 kg, lean body mass (LBM) (73.45 ± 5.94) participated in this study. Performance data were collected at Texas A&M University-Corpus Christi during two regularly scheduled practice times and once in the biomechanics laboratory. Performance data included index pinch strength (IPS), middle pinch strength (MPS), total pinch strength (TPS), and spin rate for curve balls (SRC) measured by RevFire® technology. Additionally, throwing velocity (fast ball and curve ball), standing broad jump (SBJ), height, weight, age, body composition, rotational power (RP), and hand grip strength (HGS) were obtained. Measurements were also taken for SBJ, HGS, IPS, MPS, TPS, and RP variables. Means and standard deviations were calculated for each performance variable. All pinch strength variables were analyzed by Pearson correlation coefficient (r*) against spin rate of a curve ball. The alpha level was set at* $p \leq 0.05$*. Statistical significance was found between IPS and SRC (*$r = -.61$*) and between TPS and SRC (*$r = -.47$*). The results show that index pinch strength* *specifically, as well as total pinch strength (index and middle fingers), is significantly correlated with spin rate of a curve ball. While overall strength is important to sport skills, the Magnus effect seems significantly affected by the amount of pressure placed on the ball by the index finger, which shares an inverse relationship with pinch strength. Data indicate that baseball pitchers need to be aware of how much pressure they are applying when throwing the curve ball. Therefore, particular attention should be placed on the coaches to ask questions and evaluate what the athletes feel when they pitch.*

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Today, baseball is big business. Naturally, when enormous amounts of money are at stake that are directly related to the performance of players, owners and managers are looking to quantify as much as possible to protect their investment. To be more productive financially and athletically, administrators of Major League Baseball (MLB) and NCAA schools are looking to add top talent and potential to their respective rosters. For that reason, baseball players are now measured with numerous performance tests to gauge their future impact with their team. Moreover, this statistical data have changed the game of baseball as we know it. For example, predicting what a player may be able to do in the future is often more important than present performance levels. Consequently, due to the enormous impact pitchers have on the outcome of games, this is where most of the prediction of returned value is placed. Further, many studies have been designed to assess multiple biomechanical aspects of a pitcher, including upper and lower body power, strength, and arm velocity (Escamilla, Fleisig, Barrentin, Zheng, & Andrews , 1998; Fleisig, Kingsley, Loftice, Andrews, 2006; Jinji & Sakurai, 2006; Spaniol, 2009; Szymanski et al., 2007; Wilk, Meister, Fleisig, & Andrews, 2000). Currently, many coaches in NCAA Division I baseball and MLB use the baseball athletic testing system (BATS), a test battery to appraise players' strengths and weaknesses with focus on sport-specific aspects of throwing velocity, bat speed, and batted-ball velocity (Spaniol & Hill, 1997, p. 288). However, no specific test to date is used to garner any information about how to test the effectiveness of a pitched curve ball. Additionally, no specific finger strength test, measured by a pinch gauge, and spin rate, as measured by the RevFire R1T1A, has been used to evaluate the relationship of finger strength on pitching a curve ball. Ultimately, research has led to a better understanding of the kinematic chain and the mechanics needed to increase throwing velocity (Escamilla et al.,1998; Roman-Lui, 2003). However, throwing hard is not the only thing coaches and owners need to know to evaluate pitchers.

As stated, the importance of finger strength as it pertains to spin rate and curve balls has not been extensively studied, as research is lacking in this specific area. Comparable research outside of baseball can be found in a study by Carré, Asai, and Haake (2002) that focused on a football (soccer) curve kick and in a study by Iino and Kojima (2009), who investigated the top spin of a table tennis forehand on performance level and ball spin (spin rate). Although not directly related to baseball, their findings can be applied to this study, as both studies looked at spherical projectiles and topspin, something this study looked at intently. Specifically, Carré et al. (2002) and Asai et al. (2002) determined the cause of different trajectories was due to the change of spin and impact (pressure) conditions on the ball. They also found that drag and lift increases with imparted spin (Carré et al., 2002 p. 198). Interestingly, this was the only article in which spin rate, direct impact forces, and pressure were associated with one another and therefore led to questions regarding if finger strength pressure was associated with the determination of spin rate of a curve ball. Further, Iino and Kojima's (2006) study concluded that when racket velocity increased there was a proportional increase in the ball spin (spin rate) of the forehand topspin. Conversely, their study did not take into consideration the impact forces generated by the increased velocity placed on the ball.

Briggs (1959) conducted a more baseball-specific study that investigated the spin rate of curve balls. The researcher noted that the lateral deflection (curve) of a baseball was caused by differences in the pressure surrounding the pitched ball, also known as Bernoulli's principle (1959). Bernoulli's principle states that as the velocity of a fluid is increased, the pressure is decreased (Allman, 1982; Briggs, 1959). Therefore, Briggs determined that it was this pressure differential that tended to push the ball downward (1959). Further, the force of the low pressure that is generated by the faster velocity of fluid around the ball is called the Magnus effect (Alaways, 1998; Allman, 1982). Subsequently, Briggs (1959) concluded that the velocity of the pitched curve ball had little effect in the amount that it curves; however, he did find that the spin of the ball was the greatest factor concerning the amount of Magnus effect on the ball. Likewise, Brancazio (1993) went a step further and concluded through his research that spin rate on the ball had proportional effect on the Magnus force. Similarly, Alaways, Minsh, and Hubbard (2001) elaborated on the Magnus effect, stating that they found speed had no significant contribution to the break of a curve ball due to variations of only 10%–20% on his subject population, 21 Olympic baseball pitchers in 1996 (p. 64). Further, Alaways (1998) and Alaways and Hubbard (2001) concluded in two related studies that the total break of a curve ball is nearly entirely accounted by changes in spin, which could lay within the amount of pressure is imparted on the ball. Additionally, Jinji and Shinji (2006) also studied spin rate and spin axis of a curve ball and found similar results as did Alaways and Hubbard (2001), Briggs (1959), and Allman (1982). All concluded that spin rate as a component of break was significantly responsible for an increase in the Magnus force placed on the ball. Therefore, these studies show that the amount of spin rate of a curve ball affects the production of Magnus force.

Based on these results, it was logical to determine whether the amount of pressure applied to the ball would have any effect on the spin rate of the ball, which would affect Magnus force and ultimately how much the ball would curve. Thus, the purpose of this study was to investigate the relationship between finger strength and the spin rate of a curve ball by NCAA Division I baseball players. Finger strength was determined by a pinch gauge. The pinch gauge assessed the amount of pressure applied by the participant's index finger in kilograms (kg). Spin rate was determined by RevFire R1T1A-2 Baseball Package and will be recorded by revolutions per second (RPS). It was hypothesized that there will be no significant relationship between finger strength and the spin rate of a curve ball by NCAA Division I baseball players.

Methods

This study collected performance data at Texas A&M University-Corpus Christi (TAMUCC) during two regularly scheduled practices and one session in the biomechanics laboratory. Fifteen NCAA Division I baseball players, (age 19.4 ± 1.18 years, height 183.56 ± 5.61 cm, weight 83.90 kg ± 8.41 kg, lean body mass (LBM) (73.45 ± 5.94) participated in the study. The subjects were selected by a purposive sampling method (n=15). All participants signed a consent form to participate before being tested. Also, all participants were on the active in-season roster and purposively assigned to four groups on three different testing days. The first day of testing was conducted in the biomechanics lab where descriptive data were collected which included standing broad jump (SBJ), height, weight, age, body composition-lean body mass (LBM), rotational power (RP), and hand grip strength (HGS). The second and third day of testing occurred during regular practice days where throwing velocity (MPHcurve), index pinch strength (IPS), middle pinch strength (MPS), total pinch strength (TPS) and spin rate for curve balls (SRC) data were collected. Measurements for the curve ball were taken by RevFire® technology, which is designed to measure the spin rate with an accuracy of +/- 0.25 (RPS) (RevFire, 2010, October 25). Three trials were performed for the SBJ, HGS, IPS, MPS, TPS, and RP variables; the measures were averaged for analysis. Further, five trials were taken for SRC, SCF, and MPH for both curve and fast balls, which were also averaged for analysis. Means and standard deviations were calculated for each performance variable. All pinch strength variables were analyzed by Pearson correlation coefficient (r) against spin rate of a curve ball. The level of significance was set, a priori, at $p \leq 0.05$.

During the first day of testing, the 15 pitchers were placed in four different groups, based on their pitching rotation during two days of intra-squad scrimmage. Subsequently, each group started at the height and weight station, and participants were asked their ages. Height was taken in centimeters (cm), and weight was taken in kilograms (kg) with a standard clinical scale (model ws670).

The next station was a hand grip strength test measured by a hand dynamometer. Standard protocol was used for data collection during this test, which included having the participant standing and having the tested arm bent at a right angle so that his forearm was parallel to his thigh. The handle of the dynamometer can be adjusted if required for hand size of the participant. The base should rest on first metacarpal (heel of palm), while the handle should rest on middle of four fingers. When ready, the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 5 seconds (Heyward, 2006; Hoffman, 2006). Results were taken in kg.

Additionally, the participants were tested for body composition using an Omron bioelectrical impedance device. An established protocol was followed in the use and testing with this device, which included selecting an athletic build for each one of the 15 participants, entering their height, weight, and age, and then having the participant hold the Omron thumbs up around the two grips away from his body. The results provided body fat percentages, which was used to calculate LBM.

The next test station was SBJ. The objective of this test was to measure leg power with a whole body movement action, much like the sport specific movement of a baseball pitcher. A tape measure (at least 10 feet) was secured to the floor in a straight line and a test station constructed. The participant straddled the straight line about a shoulder width apart, performed a counter movement first and then jumped as far as possible along the line of the tape measure. The distance from the starting line to the edge of the participant's nearest heel was measured in centimeters as the jump distance (Heyward, 2006; Hoffman, 2006).

From there, a large area was used in the biomechanics lab to test RP. This test measures core strength and total body power. For baseball players, it simulates the rotational core movement common to the sport. A 3 kg power ball was needed for testing. The participant extended his arms out away from his body holding the 3 kg power ball. If standing on the right side, the participant placed his left hand directly under the power ball and his right hand and the end of the power ball, making a 90 degree angle if looking at the hand placement from a lateral stance. The participant then approached a pre-determined line and drew the power ball back, with only a slight bend at the elbows, keeping the ball between the waist and chest. A power rotational explosion toward the wall was encouraged and then measured by a radar gun in MPH and converted to meter per second (m/s). This protocol was used for measurements on both the right and left side depending on the pitchers' dominant throwing hands (Spaniol, 2009).

In the next practice, pinch strength, spin rate, and velocity were taken at TAMUCC's Chapman field. Pinch strength was taken with a Baseline hydraulic pinch gauge (HiRes large head 12-0228) for finger strength assessment in kg. Pinch gauge protocol that came with the instrument was used for all data collection. The IPS, MPS, and TPS were taken before the pitchers entered their bullpen session. A participant would take a seat on the bench that was adjacent to the bull-pin. Further, the researcher held the head portion of the gauge while the participant placed his thumb underneath the finger pad. Next, the participant placed either his index or middle finger on the top portion of the pad and squeezed at maximal isometric force for three to five seconds. Total pinch strength was then collected by having the participant place both fingers on the pad and follow the previous protocol.

The final portion of data collection consisted of spin rate and velocity obtained by the RevFire R1T1A-2 baseball package. The two RevFire baseballs that were used are collegiately weighted (5 oz) with 108 double stitches that are within the specifications of the NCAA. Spin rate was measured by the corresponding instrument called the RevFire monitor, which the researcher held during throwing. Spin rate was measured by revolutions per second (RPS). At the same time, a radar gun was used at the opposite side of the RevFire monitor, behind the pitcher, for velocity measurements. A Jamar radar gun was used and readings were collected in MPH and converted to m/s. Each of the four groups followed this procedure systematically.

Results

The data was coded and the Statistical Package for the Social Sciences (SPSS) was used for the purpose of data analysis. Means and standard deviations were determined for IPS, MPS, TPS, SRC and SRF measured by RevFire®, SBJ, RP, height, weight, LBM, HGS, age, and throwing velocity for the curve ball. Results are summarized in Table 1. All pinch strength variables were measured by Pearson correlation coefficient (r) against spin rate data for a curve ball and can be seen in Figures 1,2,3, as well as in Table 2.

The 15 NCAA Division I baseball pitchers (age 19.4 ± 1.18 years, height 183.56 cm ± 5.61 cm, weight 83.90 kg ± 8.41 kg, LBM 73.45 kg ± 5.94 kg, Table 1) had a mean TPS of 16.62 kg ± 1.66 kg, a mean IPS of 8.24 kg ± .98 kg, a mean MPS of 8.41 kg ± .95 kg, while the mean SRC was found at 36.58 rps ± 4.34 rps, as seen in Table 1. Additionally, the mean throwing velocity was found at 31.69 m/s ± 1.42 m/s, the mean for HGS 26.58 kg ± 4.59 kg, LBM 73.44 kg ± 5.95 kg, RP 14.39 m/s ± 1.09 m/s, and SBJ 251.83 cm ± 11.48cm (Table 1). Statistical significance was found with the relationship between TPS and SPC (r = -.48, Figure 1, Table 2) and between IPS and SRC (r = -.61, Figure 2, Table 2) respectively. Furthermore, the relationship between TPS and HGS was found to be statistically significant (r = .78, Figure 3, Table 2).

Discussion

The major finding in this study was SRC, IPS, and TPS were significantly correlated; TPS and SRC (r = -.48, figure 1, table 2) and IPS and SRC (r = -.61, figure 2, table 2). The principles behind this are broken down into understanding how the Magus effect is proportionally affected by spin rate and the terminal finger strength and ultimate spin rate for a curve ball. Spin rate of a thrown baseball is caused by pressure placed on the baseball by finger strength proportionally contributing to the Magnus effect on the thrown pitch (Alaways, 1998; Allman 1982; Briggs, 1959; Brancazio, 1993). Specifically, spin rate and its proportionality to Magus Effect was found to have an inverse relationship with finger strength in this study. Interestingly, it was not the strength and power of the 15 participants that influenced this outcome. Rather, it was the controlled manner of the amount of grip pressure that ultimately determined the spin rate and Magnus effect on the ball.

As with all studies, this one must take into account many other variables that may play a role in findings. Mindfully, Alaways and Hubbard (2001) stated in their study that Sikorsky and Lightfoot (1949) had suggested that seam orientation played a notable role of lift and trajectory of a four seam curve ball. In contrast, it was later found by Watts and Ferrer (1987) that seam orientation played less of a role when spin rates were higher (>.4RPS), as commonly found in curve balls. Additionally, Alaways (1998) discovered that the drag coefficient for a baseball is minimized due to the fact that it takes less than a half second for a baseball to reach the catcher if thrown from a regulation mound, 60’6” from home plate. Importantly, neither drag nor seam orientation played a big role in the amount of spin rate, which demonstrates the importance of spin rate and how it proportionally affects the Magnus force placed on the ball (Alaways et at., 2001; Briggs, 1959; Brancazio, 1993). Therefore, as explained by Bernoulli’s principle, it is the difference in high and low pressure acting on opposing sides that influences the ball to curve (Alaways, 1998; Allman, 1982; Briggs, 1959).

Similarly, Carré et al. (2002) found when spin rate is increased, the predicated curved path is greater when considering the flight in a gas fluid state (p. 196). Additionally, Iino and Kojima (2009) found that improved top spin related to increased spin rate had greater effects in ball movement in table tennis (p. 212). Consequently, when spin rate is increased, the trajectory of the spherical objects was exacerbated by an increased Magnus force (Briggs, 1959). Ultimately, these findings, though outside the baseball domain, strengthen the evidence found in this study.

The results of this study illustrated that the greater the spin rate, the farther the ball curves due to an increased Magnus effect, as found in many studies (Alaways, 1998; Briggs, 1959; Allman 1982; Brancazio, 1993). In particular, this finding coincides with statistical evidence from Briggs (1959) and Alaways et al. (2001), which found the amount of break of a curve ball caused by Magus Effect is greatly affected by the spin rate of the baseball. However, a delicate balance must be achieved in order for a curve ball to obtain optimal performance. Therefore, this study proposed a dynamic system approach for evaluation and analysis. Moreover, this system is composed of two components. The first is applied finger strength or pressure of the index and middles fingers. The second facet is spin rate of a thrown curve ball. Concerning the first component, a stronger negative correlation is seen with the index finger and spin rate, $r = -.61$, than with the middle finger and spin rate $r = -.21$. Biomechanically, this may be due to which finger is the last to apply force on the ball when released. However, as the results suggest, as the amount of applied pressure increased on the baseball, the RPS decreased. As discussed by Briggs (1959) and Alaways et al. (2001), it is natural through our understanding of physics to expect a spinning projectile flying through a fluid environment to interact with the gas around it to form boundary layers around the projectile (baseball). Further, the researchers stated that the new-formed low pressure on the south side of the ball would increase the velocity of the fluid traveling around it (Alaways et al., 2001; Briggs, 1959). Therefore, it stands to reason that the last finger on the ball, the index, would impart the most important pressure to the ball as it is the last finger to influence spin rate. However, the second component of the dynamic system approach states spin rate can only affect to a sub-maximal level according to the results of this study. Spin rate was seen at a higher RPS when the participants were averaging less finger strength or pressure on the ball. Interestingly, the findings suggest a curve ball has a delicate balance of appropriate finger pressure, or a terminal pressure, to impart an optimal spin rate to achieve the greatest Magus Force. Although studies have previously suggested an increase in Magus Effect could be achieved by increasing spin rate, none of these studies specifically examined finger strength as the catalyst or inhibitor to spin rate. Therefore, based on the findings of this study and the collective knowledge of previous curve ball studies, the results seem to allude to a terminal finger strength pressure that can be placed on the ball to obtain optimal spin rate; that is, if the pitcher goes over the terminal pressure, the added force will be detrimental to the curve ball, slowing the spin rate, and thus decreasing the Magnus Force. In contrast, if the pitcher can maintain optimal terminal pressure, specifically the index finger, spin rate will increase leading to an increased Magnus Force imparted on the ball. Ultimately, a small pressure change specifically in the index finger could make a huge difference in the effectiveness of a pitcher's curve ball.

Conclusion

To conclude, the present study demonstrated that while overall strength and power are important factors in performance as a pitcher, the overall system dynamic of finger strength and spin rate determines how much the Magnus effect will influence the trajectory of the curve ball. Further, the last finger imparting pressure on the ball, the index finger, may be the reason why there is a higher correlation with the IPS and SRC as opposed to MPS and SRC. Additionally, research suggests within this dynamic system of strength (pressure) and spin rate, a terminal amount of strength can be added before it becomes detrimental to maximal spin rate. Therefore, future studies should be conducted that measure pinch strength and optimal gripping pressure for desired pitches to achieve the most advantageous spin rate for best performance.

Applications in sport

The data suggest that baseball pitchers need to be conscious about how much pressure they are applying with their fingers while throwing a curve ball. Moreover, research indicates that when terminal pressure is neared, optimal spin rate may be achieved. However, if terminal pressure for the desired spin rate is passed, it will carry a negative effect on the curve ball's performance. Therefore, particular attention should be placed on coaches to ask questions and evaluate what the athlete feels when throwing pitches. Specifically, they should ask pitchers to narrow their focus to the feel of the pitch. Ultimately, the information learned can be used as a teaching aid concerning increasing a pitcher's performance.

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