“Correlation of Grip Strength and Spin Rate as it Relates to Fastball Pitches for Adolescent Athletes”

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LITERATURE REVIEW

Baseball banned foreign substance use on baseballs in 2021 due to the clear advantage pitchers were having over hitters performance wise. Foreign substances, such as pine tar, spider tack, glue, and others, were increasing spin rate of the pitches being thrown by increasing the grip on the ball. This led to a decrease in pitcher's earned run average (ERA) and an increase in strikeouts (Yellon, 2021). As a result, pitchers and coaches have had to investigate other methods of influencing spin rate to try and keep the pitcher advantage. Previous researchers (Neiswender, 2022, Belisario et al, 2022) hypothesized a possible correlation of spin rate with grip strength, but ended up finding no correlation. In addition, no previous studies looked at the impact improving grip strength within a targeted training program had on spin rate. This study aims to approach the question of the relationship between grip strength and spin rate by evaluating the variables before and after a targeted training program to improve grip strength with the hypothesis that there will also be a correlated increase in spin rate.

Spin rate is defined as the number of revolutions per minute (rpm) of a baseball after it is released by a pitcher (Goff, 2021). The average spin rate for a professional pitcher, with a fastball velocity of 92 mph, is approximately 2200 rpm (O'Connell, 2016). Spin rate is important in baseball because it impacts the way a baseball interacts with the air while it is in flight. Lift forces are generated due to the Magnus effect, which stems from the motion of the ball in relation to the air molecules and results in either lift or drop depending on whether top or back spin is applied to the ball at the moment of release. When a fastball is thrown with backspin, the upper surface of the ball will be moving in the same direction as the air molecules surrounding it while the lower surface of the ball will be moving in the opposite direction as the air molecules. Faster moving air molecules exert less pressure on the surface of the baseball, which results in more pressure being applied to the lower surface of the ball, causing upward lift (O'Connell, 2016). Fastballs thrown with above average spin rates (anything higher than 2200 rpm) would result in increased lift and minimize how much the ball drops on its way to the strike zone. Below average spin rate (below 2200 rpm) would result in drop and cause the ball to hit lower in the strike zone.

Identifying spin rate as a potential training target for pitchers is significant because hitters are used to hitting the “average fastball” (Higuchi, 2013). In 2022, the average fastball velocity was around 95 mph at the professional level (Johnson, 2022) and the average spin rate was 2,272 rpm (MLB Advanced Media, 2022). Hitters expect a fastball to drop at a standard rate based on the average fastball and spin rate. Even small deviations from what a hitter internally predicts can be enough to cause failure on their end and success for a pitcher, defined as a strike. A study was done to test three different spin rates, all thrown at the same velocity, and the correlation to the hitter accuracy in hitting the pitches (Higuchi, 2013). The results indicated that pitches with the average spin rate were hit the most frequently, and both high and low spin rates resulted in more strikes for the batter (Higuchi, 2013). From this study, researchers concluded that for pitchers to have the most success, they should throw pitches as far from the average spin rate as possible. Another study was done that supported these results and found that hitters swing and miss more frequently with high spin rate fastballs compared to average spin rate pitches (Day, 2013). This study also found that the high spin rate fastballs were missed by batter at a higher frequency than even the low spin rate pitches. Chart 1 supports these claims, showing how the whiff rate of a hitter (swinging and missing) goes up with higher spin rates per velocity (O'Connel, 2016).

	Spin											
Velocity	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
83			0.0%	1.1%	4.3%	11.6%	10.0%	5.7%				
84			1.8%	2.8%	4.5%	5.9%	3.8%	7.1%	10.5%			
85			0.0%	0.0%	3.5%	3.4%	5.2%	3.6%	4.4%			
86			5.9%	3.1%	2.8%	5.9%	4.7%	4.0%	5.9%	8.7%		
87			5.0%	2.0%	3.5%	4.3%	4.9%	4.6%	5.1%	6.6%		
88		5.2%	3.4%	4.4%	4.0%	4.3%	4.3%	5.4%	7.5%	6.9%	8.5%	
89	4.8%	2.0%	3.3%	4.3%	5.5%	3.5%	5.1%	5.7%	5.9%	6.0%	8.9%	
90	1.9%	5.5%	4.1%	3.5%	4.6%	5.0%	5.3%	5.6%	7.5%	8.4%	10.3%	4.3%
91	7.9%	4.1%	3.7%	3.9%	4.8%	5.4%	6.5%	6.8%	6.8%	7.8%	9.2%	7.9%
92		7.0%	4.1%	5.2%	5.2%	5.9%	6.5%	7.1%	7.6%	8.3%	8.7%	10.4%
93	1.8%	1.9%	4.1%	5.2%	5.2%	6.9%	6.7%	7.5%	8.3%	9.6%	9.6%	12.2%
94	5.6%	3.9%	3.1%	5.2%	5.6%	6.8%	7.4%	7.9%	8.5%	9.2%	10.9%	11.4%
95		1.5%	4.7%	6.6%	6.4%	7.3%	8.1%	8.7%	10.1%	10.0%	12.0%	12.4%
96			14.0%	6.8%	5.9%	7.4%	8.9%	9.3%	10.2%	10.8%	11.3%	12.5%
97				4.7%	7.4%	7.8%	8.9%	9.8%	10.9%	12.8%	13.6%	19.2%
98					8.2%	7.6%	9.3%	10.5%	11.7%	13.2%	13.3%	16.8%
99					5.4%	10.2%	9.1%	11.2%	12.8%	13.4%	16.0%	19.7%
100						9.7%	11.2%	9.1%	14.3%	17.2%	18.0%	

Chart 1 (O'Connel, 2016). Whiff percentages of fastballs at various velocities and spin rates

These studies suggest that batters hit fewer pitches above or below the average spin rate, and that high spin rate pitches are the most difficult for hitters to make contact with (Aviles, 2021). This prior research has shown the benefit of high spin rates for pitching success, which has led pitchers and coaches to pursue training methods to increase spin rate, now that the previously used substances are no longer an option.

The biggest obstacle to increasing spin rate for a pitcher is the lack of time during the delivery of a pitch to impart spin. According to Matsuo, there is a 5-6 ms window where force can be imparted on the baseball to cause the necessary backspin for a fastball. This window occurs immediately after the thumb slips off of the baseball and ends when the middle and index finger are no longer in contact with the ball (Matsuo, 2013). This makes spin rate hard to consciously influence and impact in real time. This incredibly short period of time is what made foreign substances so effective. By increasing the friction on the ball, the fingers were able to hold onto the ball longer (Goff, 2021), which allowed for the application of force over a longer period of time This maximized that 5-6 ms window and resulting in greater spin at the moment of release (Matsuo, 2013). Without those substances, other avenues for increasing spin rate are needed.

Since the duration of force application is so short and not easily increased without the foreign substances, the next option for increasing spin rate is with the amount of force being applied to the ball in that window. Numerous previous studies have evaluated the correlation between grip strength and spin rate. One study investigated this correlation with curveballs, where topspin was imparted on the ball instead of backspin (Woods III, 2018). This achieves a forward spin on the baseball instead of backspin, leading to movement with gravity instead of against gravity like a fastball. This study actually found a negative correlation between grip strength and spin rate, however, there are many variables in this study that likely contribute to the negative correlation; the biggest being that it is a curveball instead of a fastball which can have much higher spin rates than fastballs at far lower velocities (Petriello, 2016). In addition, different mechanics are used to throw curveballs compared to fastballs. Curveballs are thrown with wrist supination versus pronation for fastballs, which may even support the hypothesis that grip strength will impact spin rate for fastballs since the mechanisms are opposite to those of curveballs. Another study found a correlation between finger length and spin rate, but when velocity was accounted for, grip strength had no correlation (Belisario et al, 2022). With foreign substances having only been banned as of 2021, the results of these prior studies indicate that this area of research is still developing.

If the goal is to maximize the amount of force being applied to the baseball through the fingers, then grip strength may be an ideal focus for pitchers looking for alternatives to the newly-banned substances. Improved strength for muscles, in general, has shown to lead to greater peaks in force and power production (Fitts et al., 1991, Peterson et al., 2006) and this holds true for the forearm muscles. This research suggests that improving grip strength may allow for greater force production through the forearm flexors, which would lead to greater force application to the baseball. Research shows that the greatest quadrant of force production of the fingers (between abduction, adduction, extension, and flexion) is flexion (Li et al., 2003). This means that strength training for the forearm flexors should impact the throw, since a baseball is thrown in a finger extension-flexion co-contraction, during the 5-6 millisecond window (Matsuo, 2013). Improved strength, leading to greater force being put into the baseball during the pitch, has the potential to result in a higher spin rate. Based on the results of these prior studies and the current study design, it is expected that the results of this study will fill in some of these gaps in the research and show a positive correlation between grip strength and spin rate.

One of the concerns regarding research in this field is that increased spin rate results from improved strength, if found to be true, could be biased towards older athletes. Older athletes generally throw harder than younger ones which would lead to skewed spin rate data, since velocity and spin rate are directly correlated (O'Connell, 2016). When a pitcher throws faster (95 mph vs 85 mph), the angle they release the ball at is lower in comparison to the slower pitch (Kanosue 2014). A lower release angle allows the index and middle finger to impart force on the ball longer. Increasing the time the pitcher can apply force on the ball translates into a higher spin on release. Any spin rate gains from specific forearm training could be hidden by the fact that older athletes throw with more velocity. Until recently, there was no specific statistic to compare spin rates across different velocity ranges. In 2016, a new statistic was introduced to address this: Spin Rate to Velocity Ratio (SVR), sometimes called the Bauer Unit after pitcher Trevor Bauer (O'Connell, 2016). SVR takes spin rate (rpm) and divides by velocity (mph). This variable is used to compare spin rates across a wide range of velocities. A pitcher throwing at 95 mph with a spin rate of 2400 rpm would have an SVR of 25.26. This could then be compared to a pitcher throwing at 90 mph with a spin rate of 2300 rpm and SVR of 25.56 (O'Connell, 2016). The higher the SVR, the further from average the pitch, and the more difficult it becomes for a hitter to make contact with the ball. The SVR statistic is very important for spin rate analysis because, especially for youth pitchers, it gives a way to compare spin rate relative to speed. This is useful for both comparison between athletes who throw at different velocities, as well as for following athletes as they grow in the sport. As young athletes mature both physically and in their pitching ability, the SVR can be used to evaluate their performance over time relative to their pitch velocity at each stage of their development. For the purposes of this study, using SVR will separate out any biases the harder throwers have compared to the slower throwers.

The hypothesis of this study is that improved grip strength will have a positive correlation to spin rate. This improvement is expected to be a result of increased force production during the window of release of the ball. This study will focus on high school-aged pitchers and will use SVR as the main indicator of change, to allow for the best comparison between athletes, but also for each athlete as an individual (athletes are expected to throw harder at the end of training). Because this area of research remains a relatively new focus for pitchers looking for options to improve their spin rate; this is a topic that has the potential to have wide-ranging effects on whether grip strength may be an important focus for the future of pitcher training.

METHODS

This study was performed alongside a training program for high school-age baseball pitchers held at an elite baseball training facility. Forty-four athletes from the training program consented to participate in the study. The program began with pre-testing in mid-October, continued through the winter with strength training and pitching mechanics instruction, and ended with post-testing in mid-March prior to the beginning of the high school baseball season, after approximately four months of training. Pre and post-testing were measured on 2 separate days and consisted of a Grip Strength Day and a Velocity Day.

Grip Strength

On the Grip Strength Day, each athlete performed 3 trials of a maximal grip strength measurement using a hand grip dynamometer (Creative Health Hand Dynamometer T-18, Smedley III). The dynamometer was held with the throwing hand

and arm by their side with the elbow flexed to 90°. The athlete squeezed the dynamometer with maximum effort for 3 seconds before releasing it (Balogun et al., 1991). The best attempt was recorded as their pre-testing grip strength.

Spin Rate and Velocity

The Velocity Day included measurements of their spin rate and fastball velocity using a Rapsodo unit. The Rapsodo unit is a high-speed camera used to measure the movement profiles of a pitch and predict the flight of the baseball based on the spin it exhibits. Each athlete threw a total amount of 15-30 throws, depending on the athlete's conditioning and quality of the pitches due to the Rapsodo unit only measuring pitches within the strike zone. Five throws were used to calculate the pre-testing fastball velocity and spin rate. For athletes that threw more than five measurable pitches, the five used for the calculation were selected at random.

Grip Strength Training

After completing both pre-testing days, athletes with average to high spin rates were randomly split into two groups: the Test Group or the Control Group. Low-spin-rate athletes were excluded from this study, based on research indicating that both high and low spin rates are beneficial for the pitcher (Higuchi et al., 2013). Athletes were deemed "low spin rate" if their SVR was two standard deviations away from the average. If the spin rate improved with grip strength, as hypothesized, low spin rate athletes would possibly increase their spin rate to what is considered average, resulting in poorer outcomes for the pitchers. In addition, any athletes with current or previous injuries that could have impacted their participation in the training program were also excluded.

The training program began in October and consisted of 1-2 lifts a week until March. Both the Test and Control Groups completed a general strength program as part of the pitching training program. The Test Group completed an additional 2 exercises specific to grip strength during each lifting session, while the Control Group completed 2 additional exercises that were unrelated to grip strength. The Test Group alternated between 4 grip strength exercises depending on the general workout assigned for each strength day. The exercises options included 3x30 second full body hangs from a pull-up bar, 3x15 yds walk with dumbbells in both hands, 3x30 reps on the grip strength trainer, and 3 sets of wrist rollers (a free weight exercise where a weight was put on a rope attached to a horizontal pole. The weight was moved using a rolling/pulling motion of the forearms).

Post-Training Testing

The Grip Strength Day and Velocity Day were repeated in March, for post-training data collection with all the same measurements taken as with pre-testing. A total of thirty-seven athletes had their post-testing data collected.

Statistical Analysis

Pearson's correlations between grip strength and SVR were run on both the pre-testing and post-testing data for each group. Paired samples t-tests were used to compare pre-testing data to post-testing data for grip strength and SVR within each group. Independent samples t-tests were used to compare the pre-testing and post-testing grip strength and SVR between the groups.

RESULTS

Pre-testing measurements of grip strength, spin rate, velocity, and SVR are shown in Table 1. Seven athletes were dropped from the study due to either injury or incomplete participation in the training program. All statistics were only run on athletes that completed the study in its entirety.

Table 1. Pre-testing Measurements Between the Test and Control Groups.

	Test	Control
Athletes (n)	19	18
Grip strength (kg)	50.09 ± 8.51	48.60 ± 9.23
Spin rate (rpm)	1975.88 ± 223.60	1986.16 ± 145.90
Velocity (mph)	78.38 ± 5.60	78.86 ± 4.72
SVR	25.44 ± 2.05	25.32 ± 1.72

The independent samples t-test comparing the grip strength of the Test and Control Groups at pre-testing showed no significant difference between the two groups ($p=0.14$). In addition, the independent samples t-test comparing SVR between the groups showed no significant difference ($p=0.47$). There was no correlation between grip strength and SVR for either the Test ($r=-0.22$) or the Control ($r=0.04$) Group at pre-testing. Post-testing measurements of grip strength, spin rate, velocity, and SVR are shown in Table 2.

Table 2. Post-testing Measurements Between the Test and Control Groups.

	Test	Control
Athletes (n)	19	18
Grip strength (kg)	52.83 ± 9.20	48.52 ± 10.33
Spin rate (rpm)	1941.8 ± 268.69	2009.13 ± 201.70
Velocity (mph)	79.79 ± 5.37	81.65 ± 4.90

SVR	24.39 ± 2.78	24.64 ± 2.42

There was no significant difference in the grip strength for the Test Group from pre- to post-testing ($p=0.13$). Similarly, the paired samples t-test for grip strength for the Control Group showed no significant difference from pre- to post-testing ($p=0.21$). There was also no significant difference in the SVR from pre- to post-testing for either the Test ($p=0.32$) or Control ($p=0.25$) Groups.

There was no significant difference on the independent samples t-test between the Test and Control Groups for grip strength ($p=0.26$) or SVR ($p=0.60$) at post-testing. In addition, there was no correlation between grip strength and SVR at post-testing for either group ($r=-0.15$ and $r=-0.27$, respectively).

CONCLUSIONS

The purpose of the study was to investigate whether improvements in grip strength would be correlated with similar improvements in SVR. The hypothesis was that improvements in an athlete's grip strength would show a positive correlation to increased fastball SVR.

The results of this study found no correlation between grip strength and SVR at pre-testing or post-testing. This is consistent with the data found in the study performed by Belisario (2022) which also found no correlation between grip strength and SVR. However, the hypothesis was that an increase in SVR would be the result of improved grip strength. Since the Test Group showed no significant improvements in their grip strength, the hypothesis was not adequately tested. These results suggest that a potential limitation may have been that the grip strength exercises for the Test Group were not sufficient to produce a change in grip strength over the course of the training program. It is possible that there may be a correlation between improved grip strength and increased SVR that was not observed due to the lack of change in grip strength.

Another factor contributing to the lack of results may have been the size of the population. A larger sample size may have shown different results that could indicate possible significance in the relationship between grip strength and SVR. Another limitation of this study was that athletes were only required to lift in person once a week. The other lifting days were done independently and were unsupervised. As the trainers were only able to observe athlete participation once a week, the lack of improvement in grip strength may have been impacted by underperforming on the unsupervised training days. Associated with this were the requirements put upon the trainers for the volume of grip strength exercises they could prescribe. The combination of having arbitrary limits on exercise type, repetitions, and sets and the athletes lifting unsupervised may have resulted in a lack of strength adaptations. This volume limitation may be the underlying cause for the observed maintenance of grip strength for the majority of the athletes who participated in the study rather than the expected increase. Additionally, all of the athletes did some level of grip strength training regardless of their group, as grip is a factor in other exercises, such as deadlifts and bench press. This may have also minimized the differences observed between the two groups.

Based on the data collected and the above-mentioned limitations, this study did not identify a significant relationship between grip strength and SVR. However, there are additional grip-related factors that may be the next potential focus for athletes and coaches looking to improve SVR. One of those factors is the way the athletes grip their fastball. As brought up by Woods III (2018), spin rate can be influenced by finger dominance on a baseball (index dominant vs middle finger dominant). Since the fingers apply force to the ball during a fastball pitch (Matsuo, 2013), finger dominance may be a contributing factor to the amount of force imparted to the ball and how that impacts spin rate and SVR. A similar issue was raised by Belisario (2022) regarding how tight each athlete actually gripped the ball, referred to as their perceived grip. Every athlete has an amount of pressure that they are comfortable putting into a baseball. When trying to quantify the relationship between grip strength and SVR, comparing an athlete who perceives himself to only be lightly holding the ball, and therefore using very little of his grip strength, to one who perceives himself to be "choking the ball" and using a high percentage of his grip strength, could lead to skewed results. Quantifying perceived grip is still in its infancy as a data source, but may help account for the differences in the way each athlete applies force to the ball through their fingers which could then have an impact on spin rate and SVR.

In conclusion, this study did not find a correlation between improved grip strength and SVR. While this is consistent with prior research, there is still the possibility that with a more targeted training program and larger sample size, there may be a relationship between the variables. In addition, research into the influence of finger dominance and actual force imparted to the ball in the way the athlete grips the ball on SVR are also factors that should be investigated in determining effective ways for pitchers to increase their SVR to minimize batter success at the plate.

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