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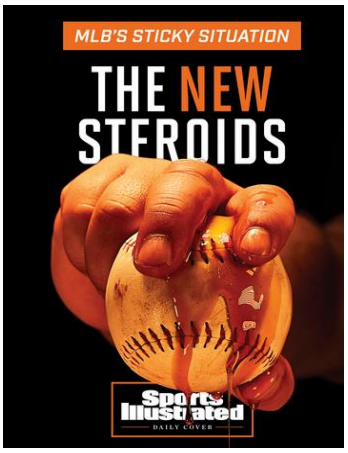
Methods to Improve Fastball Spin Rate

In June 2021, MLB announced that it would immediately begin enforcing its long-standing but rarely enforced prohibition against pitchers applying foreign substances to the ball or their fingers to increase the amount of spin they can impart on a pitched baseball.

Why the change? As ball tracking technology made it possible to quantify the impact spin rates can have on ball movement and performance, pitchers increasingly turned to foreign substances to improve their spin rate. The effect on offensive performance became pronounced. Through the first two months of the 2021 season, the league batting average (.236) was on pace to be the lowest in history.



In his June 2021 statement announcing announcing MLB's plan to crackdown on pitchers using "sticky," Commissioner Robert D. Manfred, Jr. stated, "there's a history of foreign substances being used on the ball, but what we are seeing today is objectively far different, with much tackier substances being used more frequently than ever before." He added that, "foreign substance use had gone well past the need to get a better grip on the ball, thus giving pitchers an unfair advantage. The point of the ban was to level the playing field" (1).

How spin rate affects ball movement? From a physics standpoint, the seams on a spinning baseball are acted upon by the air due to a principle termed the Magnus effect.

While it is beyond the scope of this paper to provide a detailed explanation of the Magnus effect, it has been well-established in the literature that provided the spin is in the proper direction (i.e. efficient spin), the greater the spin rate on a pitched ball, the greater the pitch will deviate from the path it would otherwise travel from the pitcher's hand to home plate if it were only influenced by gravity. For a detailed explanation of the Magnus Effect, see (2).

Generating more efficient backspin on a 4 seam fastball will produce greater lift or "ride." More efficient topspin on a curve ball will produce greater downward break. And more efficient side-spin will produce greater horizontal break (3).

While most of the same principles would apply regardless of the pitch type, unless stated otherwise, we will focus primarily on the methods to improve fastball spin rate throughout this paper. Additionally, while not a focus of this paper, we acknowledge the impact of "seam-shifted wake" in ball movement.

HOW TO INCREASE SPIN RATE

According to a Driveline post in 2019, four variables have been found in varying degrees to increase spin on a baseball (4):

1) Velocity
2) Spin axis
3) Finger strength
4) Friction

1. Velocity

Multiple studies have shown a strong correlation between velocity and spin rate.

a) In its 2016 study, Driveline had 5 pitchers throw fastballs between 60-80 mph using the same fastball grip (Exhibit 1). They found a .91 correlation between velocity and spin rate (5).
b) In 2022, a team of Japanese researchers found a .80 correlation between velocity and spin rate when studying 13 college and high school pitchers who threw an average of 80 mph (6).
c) In a 2008 study titled "Direction of Spin Axis and Spin Rate of the Pitched Baseball" involving 23 pitchers, the researchers found a .91 correlation between spin rate and velocity (7).

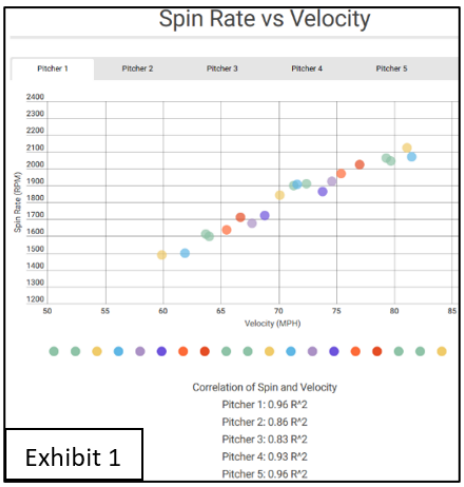


Exhibit 1

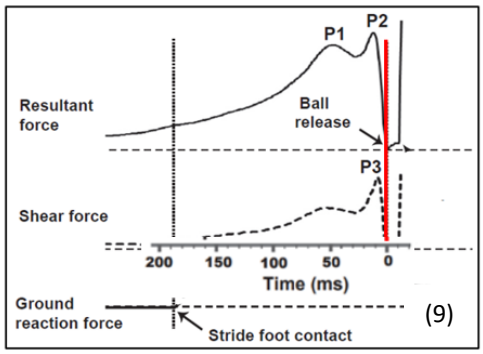
While there is a strong correlation between a spin rate and velocity, if the goal of increasing spin on a fastball is to increase movement, it is worth noting that any spin increase due to an increase in velocity will not alter overall pitch movement. The reason: a ball thrown at a faster speed will have less time in its path to home plate to be impacted by the Magnus effect, such that this faster speed will negate any additional movement that one could expect if spin increased and velocity were held constant. This faster speed would also reduce the amount of time gravity could impact the ball's flight, which would decrease the vertical approach angle of the pitch.

2. Spin Axis

Pitches with more glove side movement such as cutters, curveballs, and sliders have been found to have higher spin rates than a 4 seam fastball, perhaps owing to greater supination of the forearm, ulnar deviation, and wrist flexion when compared to pitches with natural run or fade (8). While it is possible to increase the spin rate on a fastball by introducing more "gyro" spin, aside from a phenomena termed "seam-shifted wake" which again is beyond the scope of this paper, an increase in "gyro" spin is considered inefficient in that it will not contribute to the spin-influenced movement of the pitch.

3. Finger Strength

In a 2016 study a team of researchers including Glenn Fleisig, PhD from the American Sports Medicine Institute found that:



a) the shear forces imparted by the index and middle fingers milliseconds before and through ball release as shown in the adjacent exhibit have been found to be the main producer of spin, and
b) peak flexion forces on the index and middle finger often approach their strength limit (88%) when throwing with max intent (9).

Given these findings, Driveline wondered whether grip and finger strength might play a role in a pitcher's spin rate. To find out, in 2022, Driveline studied the effects of grip and finger strength on the spin rate of 51 high school, college, or professional pitchers (10).

To conduct the study, Driveline first tested the grip and finger strength of all players using a hand grip dynamometer and a pinch gauge. They then had the players throw a number of max effort fastballs (along with other pitches). Their findings:

The correlation between overall grip strength and pinch grip strength for the index and middle fingers to the spin to velocity ratio on fastballs (often referred to in the industry as Bauer units) was weak and insignificant (r = -0.01, .12, and .03), leading Driveline to conclude that overall grip and finger grip strength have no meaningful impact on a pitcher's spin rate.

Was Driveline correct? Perhaps. But our preliminary investigation of this topic suggests otherwise. Specifically, we have had numerous players report increases in their spin to velocity ratio after training on our FlexPro Grip device, causing us to wonder whether the discrepancy between our early findings and Driveline's might be due a difference in the two instruments Driveline used to measure grip and individual finger strength versus the methodology by which a FlexPro Grip device measures finger strength.

Driveline used a handheld dynamometer to measure grip strength and a pinch gauge to measure finger strength.

While state of the art at the time, we believe both these devices fail to measure the actual strength that matters to a pitcher. Unlike FlexPro Grip, which is uniquely able to measure finger strength independent of the thumb, any strength assessment recorded by a handheld dynamometer or pinch gauge is highly dependent on the strength of the thumb to provide an opposing force to the fingers.

However, when throwing a fastball, the thumb comes off the baseball roughly 10 ms before release, so other than preventing the ball from falling out of the hand while the arm accelerates, the thumb has no role in applying the flexion or shear forces on the baseball that impact spin rate (13).

As a result, any measurement of strength that involves the strength of the thumb injects an irrelevant variable into the analysis.

While we are reluctant to date to summarily dismiss Driveline's findings, we plan to study this issue further using our FlexPro Grip device.

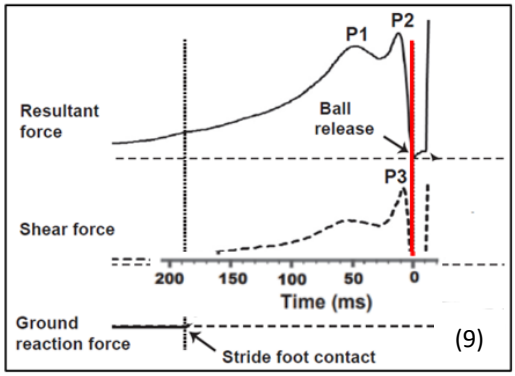
4. Friction

a) How Spin Gets Created

1) As a pitcher's arm accelerates, the ball produces force on the fingers, which if unmatched, would likely cause the ball to fly out of the hand at any point during the delivery (9).

2) To prevent the ball from flying out of the hand at any point during the delivery, a pitcher will subconsciously balance this force with their fingers by imparting a normal force on the ball in the opposite direction (11).

3) Over the course of a pitcher's delivery, three peaks of finger force occur on the baseball corresponding with maximum external rotation (P1), the ball-rolling phase (P2), and when spin gets created (P3). See adjacent chart (9).

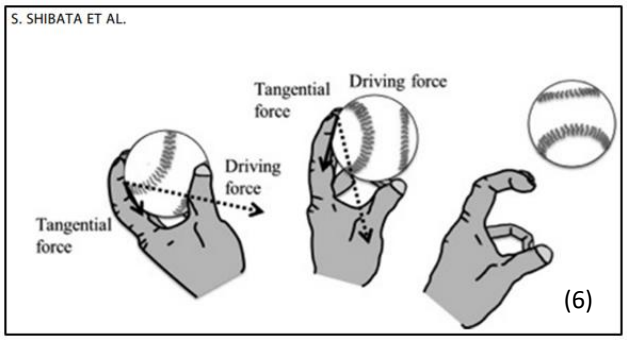


4) In the ball-rolling phase, the ball will begin to roll up the fingers of the pitcher 6-9 ms before the ball will release from his hand (9, 12).

5) Additionally, peak flexion and peak tangential (shear) finger forces occur 4-9 ms before ball release (9) at roughly the exact same time as the three finger joints (the MCP, PIP, and DIP) all abruptly and drastically flex 2-4 ms prior to ball release (12).

6) As the distal joint in the middle and index fingers flex, they impart a relatively large magnitude of shearing force onto the ball. This force acting parallel to the surface of the ball with increased friction by the seams is the primary source for generating spin on the ball (9).

7) Thus, spin rate is determined by the amount of force applied by the fingers in the tangential direction after the ball is released from the thumb roughly 10 ms before ball release, and begins to roll up to the fingertips through ball release (6).



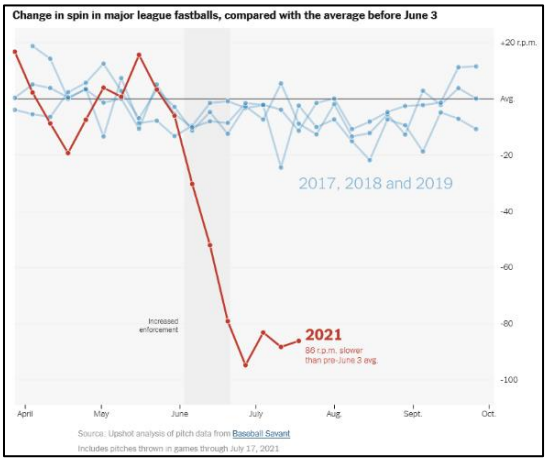
b) How "sticky" works to increase spin rate?

1) Any adhesive or "sticky stuff" applied to the fingers increases the friction between the fingers and the ball. The greater the friction between the ball and the fingers, the greater the spin imparted onto the ball as it exits the finger tips (14).

2) As the ball rolls off the pitcher's fingertips at release, adhesive or "sticky" exerts a sticking force between the ball and the fingers, causing the ball to exit the pitcher's hand with greater spin tangential to the line of force being applied by the fingers.

c) How much does "sticky" impact fastball spin rate?

Within the first 4 weeks of MLB's "sticky" ban, the average spin to velocity ratio across MLB fell 4% (86 rpm), and the top 10 pitchers most affected averaged a 9% (208 rpm) loss in fastball spin rate, so it's safe to say that applying adhesive to the fingers can increase spin rates independent of velo anywhere from 4-9% (15), impacting ball movement by an inch or more.



d) Is it possible to increase spin rate without applying "sticky" to the fingers?

What we know from the literature:

1) There is a high correlation between a pitcher's spin to velocity ratio and peak finger forces at 4-7 ms before the ball releases from the hand (r = 0.66) when peak flexion and peak tangential (shear) finger forces occur (6, 9).

2) The force imparted by the fingertips in the tangential direction 10 ms before and through release is the primary source for generating spin on the ball (6, 9).

3) To improve fastball spin rate without "sticky," a pitcher must apply greater force in the tangential direction to the baseball 10 ms before and through ball release (6).

4) Simply put, according to renowned baseball biomechanist James Buffi, PhD, "when you take away the sticky stuff – if you want to increase spin rate – you need more finger force to get the same resulting friction (16).

The prevailing opinion in baseball has been that a pitcher's spin to velocity ratio cannot be changed. Given the aforementioned factors that impact a pitcher's fastball spin rate, this means that the prevailing opinion in baseball is that other than by throwing harder (which would cause

a pitcher to accelerate his arm and hand faster and exert more finger force on the baseball), pitchers are unable to change the amount of finger force they can apply to a baseball within the 10 ms prior to ball release when spin rate is determined.

Therefore, before determining if it is possible to increase spin rate without applying glue to the fingers, two preceding questions (in reverse order) must be answered:

1) Is it possible to increase the amount of finger force a pitcher can apply to a ball within 10 ms?
2) Can the rate of force development within 10 ms be increased through training?

e) Can the rate of force development within 10 ms be increased through training?

In reviewing the literature, 3 studies make clear that with the right training protocol, this is possible.

1) In one study, 8 men who performed 4 sets of unilateral isometric knee extensions at 70% of maximal voluntary contraction for 20 seconds for 12 weeks experienced an increase in the stiffness, Young's modulus, and rate of torque development (35.8 +/-20.4%), also known as rate of force development, and a decrease in the electromechanical delay (-18.4 +/-3.8%) of their quadriceps (17).

Table 3. *Rate of torque development and electromechanical delay before and after training*

	Before	After
Rate of torque development, %MVC/s	302 ± 107	343 ± 71*
Electromechanical delay, ms	52.6 ± 5.1	37.3 ± 4.9*

Values are means ± SD. *Significantly different from before, $P < 0.05$.

2) In their extensive narrative review (18) which examined the neuromuscular determinants of rate of force development (RFD), the authors found that:

   a) Explosive-type strength training can have a large positive effect on RFD.
   b) The ability to produce force rapidly depends predominantly on the increase of muscle activation at the onset of the contraction.
   c) Roughly 40% of the variance in the force measured early in a contraction is associated with the requirement to take up series elastic slack in muscle fibers.
   d) Strength, as measured by maximum voluntary contraction, explained less than 20% of the variance in voluntary RFD over the first 10 ms of a rapid voluntary contraction.

3) In a study in which 25 males, average age 23, did 4 maximum knee extensions as fast as possible, the authors found that in the time interval up to 40 ms from the onset of contraction, voluntary and twitch rate of force development had a far greater impact than maximum strength on the force a subject could provide (19).

Once we understood that the rate at which force is applied can be increased through training, we then wondered…

d) Can training on FlexPro Grip increase the amount of finger flexion force someone can apply at 7-8ms?

To find out, in 2021, we conducted a study on 6 college pitchers who threw an average of 88 mph. Because finger flexion forces have been found in pitchers to peak on a baseball at 7ms before ball release, we first baseline tested the amount of force each participant could apply with their index and middle fingers combined at 7ms. To determine the average force each participant could apply at 7ms, after a thorough warm-up and familiarization with our FlexPro Grip device, we had users perform 10 repetitions in which they applied ballistic force with their index and middle fingers combined. We discarded the highest and lowest forces recorded and took the average of the total force recorded of the other 8 repetitions.

We then separated the pitchers into two training groups of three. Each group trained 3 times per week for 4 weeks. Group 1 performed a training protocol on a FlexPro Grip device which required them to reach their maximum flexion force slowly (verbally cued at 3 seconds) with their index and middle fingers combined, then hold that maximum force for an additional 5 seconds for 2 sets of 5 repetitions with 15 seconds of rest between each rep and set. Group 2 performed a protocol on a FlexPro Grip device which required them to reach their maximum flexion force ballistically with their index and middle fingers and hold that maximum force for 4 seconds for 4 sets of 6 repetitions with 5 seconds of rest between each rep and set.

At the completion of the study, we re-tested the amount of ballistic force players could apply with their index and middle fingers combined at 7ms using the same methodology we employed for their baseline test. The change in the amount of force users in Group 1 (the slow ramp up / strength group) applied at 7ms was 2%, -3% and -5% respectively for the 3 players for an average change of -3%. The change in the amount of force users in Group 2 (the ballistic ramp up / endurance group) at 7ms was 22%, 25%, and 28% respectively for the 3 players for an average change of 25%.

RFD results after 4 weeks of training 3x / week
(6 college pitchers)

2 training groups: Strength (3) / Endurance (3)

Training Day	2 finger flexion (@ 7ms) Strength Group	2 finger flexion (@ 7ms) Endurance Group
Baseline	3.9	4.2
Final Day	3.8	5.2
Change	-3%	25%

Protocols:
Endurance: 2 finger FDP flexion - 4 sets of 6 rep 4 second holds with 5 second rest between reps / sets. Ballistic ramp up.
Strength: 4 finger FDP flexion – 2 sets of 5 rep 8 second holds with 15 second rest betw reps / sets. Slow gradual ramp up.

Endurance -difference between Baseline 1st set high / 4th set low vs Baseline 1st set high / Final day 4th set low

Admittedly, nothing about this study would withstand the scrutiny of peer review or achieve statistical significance. However, at a minimum, it suggested to us that consistent with the well-established SAID principle (Specific Adaptation to Imposed Demand), those who trained finger flexion ballistically on FlexPro Grip could reasonably expect to see an increase in the amount of finger flexion force they could provide at 7-8ms. This then led us to our next question…

e) Would increases in the rate of force development of finger flexion on a FlexPro Grip device at 7ms cause an increase in fastball spin rate independent of velocity?

To find out, in 2022, we conducted a trial involving 8 MiLB pitchers who performed FlexPro Grip's Rate of Force Development Training protocol 2 times per week for 12 weeks while they were actively playing in the Arizona Complex League.

To gain some context as to our results, we thought it best to compare our Treatment group to a Control group.

For a Control group, we examined the change in the spin to velocity ratio of the 46 pitchers in the same organization not in our study who threw more than

50 four seam fastballs in game competition from July 1, 2021 (i.e., the start of the post "sticky" period) through July 11, 2022 (the end date of our trial) and remained healthy during this period. Notable control group results were as follows:

1) The average change in the spin to velocity ratio across all 46 pitchers in the control group was a -1% drop. If we remove the single outlier who had a -15% drop, there was a 0% change in the spin to velocity ratio across the remaining 45 pitchers.
2) Only 1 of the 46 pitchers increased his spin to velocity ratio by more than 3% and only 5 of 46 saw a 3% increase.
3) 53% experienced either no change or a slight drop in their spin to velocity ratio.

In short, the results from the control group perfectly supported the belief amongst the baseball establishment that independent of some form of adhesive or a velocity gain, it is nearly impossible to materially increase a pitcher's spin to velocity ratio.

As for the 8 pitchers who served as our Treatment group by performing the FlexPro Grip Rate of Force Development Protocol 2 times per week for 12 weeks:

1) The average increase of all 8 participants was 4% (vs 0% for the Control group).
2) 6 of the 8 (75%) experienced an increase of 3% or more (vs 6 of 46 or 13% for the Control group).
3) 5 of the 8 (63%) experienced an increase of 4% or more (vs 1 of 46 or 2% for the Control group).
4) All pitchers (100%) saw at least a 1% increase in their spin to velocity ratio (vs 17 of 46 or 37% for the Control group).

Our conclusion: despite a small sample size that warrants greater study, our trial provided compelling evidence that training with FlexPro Grip can materially increase a pitcher's spin rates and more importantly, spin to velocity ratio.

f) Would similar results apply to high school and college pitchers, and if so, would increases in a pitcher's spin to velocity ratio alter the horizontal or vertical movement of their fastball?

Our hypothesis was the answer would be "yes" to both questions, so in the summer of 2023, we conducted yet another study, this time a multi-site trial involving 46 high school and college pitchers throwing at least 80 mph.

Prior to beginning any training on FlexPro Grip, all participants provided us with recent fastball spin / movement data as measured on TrackMan from a bullpen or game, or by throwing a pen at one of our study locations. All pitchers performed FlexPro Grip's Strength Training protocol 3 times per week for 2 weeks as an onboarding program. Then, they were required to train on FlexPro Grip 3 times per week for 6 weeks, performing a 6-10 minute Rate of Force

Development training protocol. Roughly every 2 weeks throughout the study, pitchers threw on a TrackMan unit so we could track movement changes.

Results:

1) The average increase of the spin to velocity ratio of all players was 4.6%, resulting in an average increase in vertical or horizontal movement of just under 2 inches.
2) Only 1 pitcher in the entire study saw a decrease in his spin to velocity ratio (-1%). However, this pitcher continued performing FlexPro Grip's Rate of Force Development training protocol for another 4 weeks and subsequently gained 2% over his baseline in his spin to velocity ratio.
3) The highest increase was 16%, achieved by two athletes.

g) So what is it about training with FlexPro Grip that causes an increase in a pitcher's spin rate?

Dr. Gunnar Brolinson, Director of the Primary Care Sports Medicine Fellowship at Virginia Tech, offered the following explanation. "We recently began our FlexPro Grip clinical trial in October 2023, so I can't answer this question unequivocally, but I can say that based on prior fine wire EMG testing, FlexPro Grip effectively targets the muscles and tendons in the forearm that impact grip better than any other conventional training exercises. As a result, depending on the training protocol, athletes who train on the device can expect to see rapid gains in both strength and the rate at which they can apply force with their fingers. It only makes sense that gains in these 2 areas would translate into increases in a pitcher's spin rate."

Dr. Gunnar Brolinson, Director of the Primary Care Sports Medicine Fellowship at Virginia Tech

CONCLUSION:

Four variables have been found in varying degrees to increase spin on a baseball

1) Increase velocity
2) Spin axis
3) Finger Strength
4) Friction

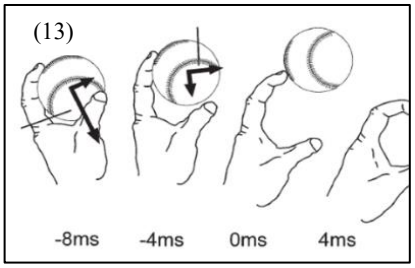
Any increase in spin rate due to an increase in velocity will not increase ball movement as a pitched ball thrown at a faster speed will have less time in its path to home plate to be impacted by the Magnus effect.

Altering the spin axis of a fastball can increase spin rate of a pitch, but this added spin, labeled "gyro," is considered "inefficient" in that it will not contribute to the spin-influenced movement of the pitch.

Anecdotally, numerous players have reported to us this past year that their fastball spin to velocity ratio increased as their finger strength increased from training on FlexPro Grip. Nevertheless, until we are able to study this further, there is no definitive proof to-date that increasing finger strength would have any material impact on increasing fastball spin rate.

According to physicist John Goff, the only way to impart more movement inducing spin on a 4 seam fastball is by increasing the friction force between a pitcher's fingers and the ball at the point of release. And there are only 2 methods, equally effective, to increase friction between the fingers and the ball at release:

1) Apply a foreign adhesive substance to the fingers or the baseball, or
2) Figure out a way to apply more flexion force with the fingers perpendicular to the ball milliseconds before ball release.



Given that MLB has deemed it illegal for pitchers to apply any foreign substance to their fingers or the baseball, FlexPro Grip's novel training device is the only known method that enables pitchers to increase the friction force between their fingers and the ball at the point of release. FlexPro Grip achieves this increase in friction by training pitchers to increase the ballistic force they are able to apply to the baseball at release with their fingers, which has led to average spin to velocity ratio increases of 4-5% across high school, college, and professional pitchers.

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