The Three Divisions of Momentum Generation of the Pitching Motion

By Dan Galaz at Galaz Baseball Technologies © 2021

Introduction

All things globally that are put in motion must be launched by some propulsion system. In this case, for a pitcher to propel the ball toward home plate (HP), he first thrust himself forward before throwing the ball. There are many ways in which pitchers are taught to throw the ball. Some of the cues used to get the pitcher moving forward are:

- Fall tall
- Drop & drive
- Drift & shift
- Shift the hips
- Ride the back leg

Some of these cues have parts of what must be considered to generate momentum proficiently before release. According to their philosophy, these prompts pitching coaches use do not conform to the physics laws that efficiently transfer momentum or energy from the ground to the ball for accuracy, velocity, and injury prevention before and after release.

When working with pitchers, we must consider how the arm is accelerated and how it should be decelerated. Why must we consider the release of the ball? After the release of the ball, the arm wants to continue moving toward HP according to Newton's 2nd law. For that reason, the arm must be given more time to decelerate to reduce the stresses in the shoulder and elbow.

Fall-Push-Pull Theory (FPPT)

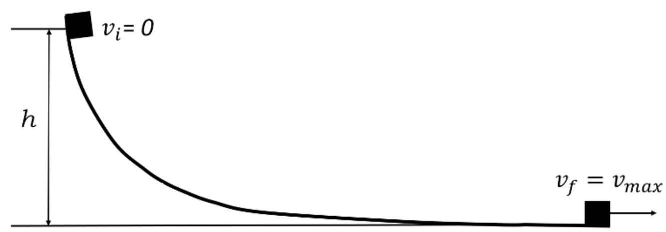
The best way to describe momentum generation down the mound is by a fall, push and pull. The fall is in preparation for the push, and the push is in preparation for the pull. In biomechanics, the push-pull principle is applied to athletes who throw and swing objects like a shot put, javelin, baseball, golf club, and bat.

The Fall

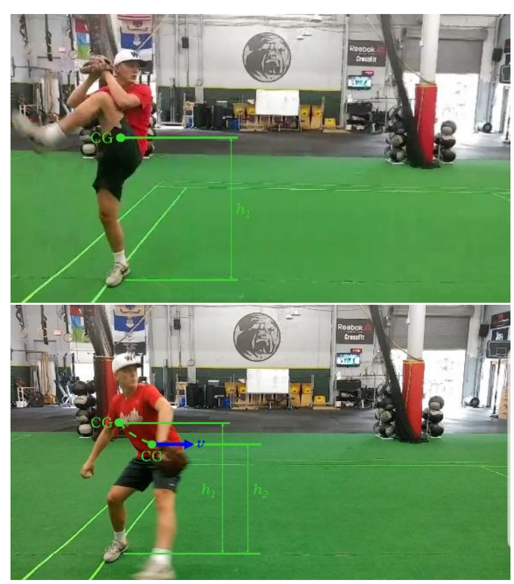
As mentioned above, the fall is in preparation for the push. The energy mechanism for the fall is the conservation of energy where potential energy (*PE*) converts to kinetic energy (*KE*), as shown below.

$$PE = KE \rightarrow mg\Delta h = \frac{1}{2}mv^2$$

A frictionless ramp demonstrates this energy conversion with a mass m at some height h. At h, the *PE* is max and released to convert to *KE*, as shown below. At the top of the ramp, the mass has an initial velocity $v_i = 0$, and as the mass is released immediately starts to convert to *KE*. At the bottom, the final velocity $v_f = v_{max}$, the *KE* is also max.



To illustrate this ramp from the pitcher's standpoint, below is a series of images of the pitcher starting from a posted position on the back leg. The taller, the better, and falls toward HP with a velocity ***v***.



In the images, the height starts at h_1 at the center of gravity CG of the pitcher. As the pitcher starts his fall, the CG ends up at h_2. On the ramp, the mass starts h and finishes at h = *0*. The pitcher, on the other hand, h_2 does not equal zero, but all that matters is the height changed from a higher value to a lower one designated by the change in height Δh in the conservation of energy equation on page 1.

The Push

Although the fall is only for a short distance, it is enough to prepare for the push of the back leg to get the pitcher's CG to the position, as shown below.

The yellow dotted line begins a new energy regime called the impulse-momentum relationship, as written below.

$$\boldsymbol{F}\Delta t = m\boldsymbol{v}$$

As the back leg starts to push with a force $\boldsymbol{F}$ for some duration Δt, it is called the impulse. The algebraic manipulation to solve for $\boldsymbol{F}$ and $\boldsymbol{v}$ gives the secrete to reducing the acceleration and deceleration stresses in the shoulder and elbow. If we solve the above equation for $\boldsymbol{F}$, we get.

$$\boldsymbol{F} = \frac{m\boldsymbol{v}}{t}$$

Simply plugging in values of t into the equations reveals that $\boldsymbol{F}$ gets smaller as t gets larger. Therefore, if we want to prevent injury, we must start by reducing the value of $\boldsymbol{F}$.

If we solve the impulse-momentum equation for $\boldsymbol{v}$, we get.

$$\boldsymbol{v} = \frac{\boldsymbol{F}t}{m}$$

If we do the same by plugging in values for t, one can determine the as t gets increases, $\boldsymbol{v}$ also increases. Therefore, a larger value of t accommodates smaller values of $\boldsymbol{F}$ and larger values of $\boldsymbol{v}$. Someone may ask, don't we want higher values of $\boldsymbol{F}$ to throw with more velocity? The impulse-momentum principle stipulates that a smaller force $\boldsymbol{F}$ applied for a longer period can produce more velocity $\boldsymbol{v}$ than a larger force applied for a shorter period. This principle should be in every coach's toolbox that works with athletes that require throwing objects.

The Pull

The pull phase of the momentum generation cycle of the PM is in a combination of two energy systems occurring simultaneously. The first is the soft tissue loading in front of the body, like the muscles, tendons, ligaments, and fascia, represented by the circular green arrow in the image below.

The loading of these tissues is stored energy called elastic energy (*EE*), another type of *PE*. This kind of loading is due to the pitcher applying an impulse $\boldsymbol{F_p}t$ from the push of the back leg, as shown in the following image. Again, the larger value of *t,* the better. Therefore, the longer the push, the more *EE* is stored to generate more velocity. This energy is unleashed when the front foot lands rigidly, as shown in the following image. The numbered green lines represent a link of the kinetic chain. The dotted green line illustrates that the solid green links 1 and 2 are rigid with minimal give to unload into KE fully.

What allows the tissue to unload in combination with muscle contraction is the impulse in reverse illustrated by the ground shear force *x* time $\boldsymbol{F_{grs}}t$. However, this impulse assists the trunk in creating an angular impulse producing an angular momentum and torque about the hips axis. The equation is written as shown below and in the angular equivalent to the linear impulse.

$$\boldsymbol{\tau}\Delta t = I\omega \implies \boldsymbol{F}\Delta t = m\boldsymbol{v}$$

In addition, there is an impulse from shoulder maximum external rotation (MER) to the release of the ball.

Proper Finish after Release

The pitcher must continue to bend to fully take advantage of the FPPT, as shown below.

Two pitchers demonstrate side by side, each in the identical position of that phase of the pitching motion. Each pair of images has implications from the first to the last set.

The position of the pitchers in the first set of images allows for:

- More linear impulse of the back leg push
- More time for the arm to load the into shoulder MER

The position of the pitchers in the second set of images allows for:

- More angular impulse generation of the trunk's forward rotation
- A later release for more time to load and unload the soft tissue in the shoulder and elbow
- Increasing the radius r of the throwing lever from the hips axis of rotation to the fingertips to increase velocity $\boldsymbol{v}$
- Releasing the ball closer to HP giving the hitter less time to see it

The position of the pitchers in the last of images allows for:

- More time for the arm to decelerate, reducing the stresses in the shoulder and elbow
- The larger muscles to get involved in the deceleration of the arm like the quadriceps, glutes, and latissimus dorsi

The green line in front of the knee represents a barrier in which the pitcher's knee must try to stay behind. If the front knee collapses beyond the green line affects the momentum transfer from the lower body to the upper body, affecting accuracy and velocity.

The Entire Pitching Motion Illustrating the FPPT

The pitcher in the series of the following images does a great job of demonstrating the FPPT. The pitcher starts from the posted back leg to the start of the fall phase until the push phase in the fourth image.

The pitcher starts the push phase until the landing of the front leg, as shown below.

The pitcher ends the push phase in the first image below, then begins the pull phase through the rest of the images.

In the last image, the pitcher finishes with his chest over his thigh and his armpit over his opposite knee (for short, chest to thigh armpit to knee). As mentioned earlier, pitchers must finish this way to protect themselves from injury to the shoulder and elbow. In the second to last image, the pitcher releases the ball further out front than most other pitchers, which helps with the proper placement at HP. Without question, the best pitch in baseball is a well-located fastball, and accuracy is a premium. Also, releasing the ball further out front increases the ball's physical and perceived velocity since the leverage is increased and the distance to HP is shortened.

<u>Conclusion</u>

Proper momentum generation and transfer have to do with a good understanding of the laws of physics. One can blurt physics terms but must also be interpreted and applied correctly. Physics is rich in insight if we are willing to dig for it, but many use physics terms loosely that do not support their application.

The FPPT is a seamless transfer of energy system from the ground to the fingertips. This propulsion system must not be rush to transmit maximum momentum to the ball entirely, explained in detail in a paper I wrote called **'Developing the Pitching Theoretical Model.'** The FPPT also accommodates in protecting the pitcher from injury due to proper acceleration and deceleration implementation. Therefore, it is not only how the pitcher starts, but more importantly, how he finishes.