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Anatomy & Physiology

UNDERSTANDING
Basic Physiology

Athletes in various disciplines do the same thing over and over again for many years, hoping to see improvement. Consequently, many athletes and coaches accept that physical maturity is the only way to improve performance. If an athlete simply continues doing the same amount of work for many years, he will eventually reach his goal. Unfortunately, sports science does not agree with this line of thinking. Hans Selye developed a general model for biological stress in the 1930s, which boiled down to three phases:

- **Alarm Stage:** *Initial stress is placed on the body.*
- **Resistance Stage:** *Recovery of the stress and increased resistance is noticeable.*
- **Exhaustion Stage:** *Chronic Stress or too much acute stress has caused maladaptation or dysfunction, and performance goes down.*

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In the 1970s, Hungarian scientist Nikolai Jakowlew put forth the concept of **supercompensation**, around which most informed coaches base their training. Jakowlew built his ideas around single-factor supercompensation, in which an initial fitness level is observed before applying a training stress. Immediately after the training stress, the target level of fitness is decreased due to fatigue from the training. Later, recovery kicks in and allows the athlete to enter a period of supercompensation, where the now-current fitness level surpasses the initial fitness level.

If another training period is scheduled before the recovery portion completes, **overtraining** may occur, possibly causing negative effects or even injury. At the same time, if a training period is scheduled too far out from the previous training session, the positive effects of supercompensation may be lost. This is where the concept of **training economy** comes into play, particularly with creating a holistic program that properly integrates strength and throwing training to meet the athlete's needs and avoid overtraining—each individual athlete only has a certain total training volume threshold he can withstand before his body breaks down. For training-economy application, check out our website for additional resources.

It's easy to see how timing and recovery play a vital role in any athletic-training endeavor—yet that doesn't stop the average gym-goer from sitting on the bench press and putting up 225 lb. every single training session for the same amount of reps and sets or pitchers from never exceeding 120 feet between the two-throwing partners while throwing in the outfield.

This simple model of fitness improvement is sufficient for **beginner** trainees, but not for trainees that are more advanced. Beginner trainees are not necessarily athletes that have just started throwing; rather, they have a low tolerance for work capacity and a low threshold for developing a high fitness level. For the purposes of our training programs, all athletes are considered beginners at the onset of their training periods. It's natural to disagree with this idea at first, particularly if there are athletes who are exceptionally skilled for their age group—to reiterate, "beginner" is not a negative descriptor: it's just a way to label training levels. As you continue to look through our programs, you'll notice that most of what we write for athletes in their first year of training with us attempts to effectively on-ramp them into more intense training routines in the distant future. If you have ever had the pleasure of training on a program with a heavy squat-based workout day, then you know the first few weeks of heavy squatting causes severe delayed onset muscle soreness (DOMS). Training for the first few weeks with the PlyoCare and weighted-ball training protocols outlined in *Hacking the Kinetic Chain — Advanced Pitching* can and often does produce short-term soreness and discomfort in areas that had previously never been stimulated.

As an athlete sticks to a program and develops fitness through a well-modulated training program, a plateau will be reached where the athlete starts to see fewer and fewer gains, which come after much longer intervals of time. This places an athlete in the **intermediate** category, where training complexity must go up. The goal is no longer to see increased results from workout to workout, but rather on a longer time horizon achieved by planning ahead. Mark Rippetoe explains these stages rather well in the books Starting Strength and Practical Programming for Strength Training, and anyone looking for more information on these topics is highly encouraged to purchase said material.

The two largest factors that cause trainees to regress in their ability level are excessive time off from training and loss of lean body mass. Athletes who do not adequately maintain their levels of achieved fitness will find themselves quickly losing their hard-won gains. Those who do not pay enough attention to proper nutrition and maintenance will lose lean body mass, which extends recovery time and reduces fitness levels as well.

Mechanisms of Adaptation

Adaptation is simply the decreased physical response to a stressor on the body due to constant exposure to the stressor. For example, after prolonged exposure to loud construction noises, that noise level blends into the background and is not perceived as loud as it was when it started.

This phenomenon is a double-edged sword and closely ties into **stress response cycling**. As an athlete continues to train by throwing PlyoCare balls for throwing fitness and mechanical-sequencing purposes, the arm gets stronger and the mechanics become more efficient. However, over time these workouts become part of what the athlete must do. The workouts transition into a "maintenance" cycle that the athlete must continue as long as he plays baseball to ensure that throwing fitness and mechanical patterns do not regress. To make further improvements, the athlete must increase stress levels or change the modality of training.

Adapting to workouts determines how an athlete's maintenance program will be chosen and designed. What used to be a grueling workout that taxed the athlete's body can now simply become a daily warm-up. This clear adaptation to the stressor not only shows how the athlete has become significantly stronger but also holds true across all domains—strength, endurance, plyometric ability, etc.

Multi-factor training is the method by which this program improves an athlete's skill level across many domains simultaneously to maximize overall gains. All throwing drills done at high intensities are multi-factor, which means many changes are happening, but not all of them are positive:

- *Physical mechanical pattern is changing based on the demand or drill being performed (positive)*
- *Positive structural changes are occurring: muscle recruitment, increased mobility around targeted joints (both positive)*
- *Central nervous system is becoming more efficient at coordinating motor units (positive)*
- *Negative structural changes can occur due to initial faulty technique and/or general stress: decreased internal rotation of the shoulder, decreased elbow flexion/extension range of motion (both negative)*

While using a multi-factor training methodology maximizes efficiency and overall return on training time, it is vital to manage the negative adaptations that occur from a high-intensity training program. Recovery plays an enormous role in our training programs. While we understand that nobody makes it to the show based only on an ability to stay healthy, athletes can only consistently train at a high level if they recover properly from their previous training sessions. This principle only becomes more important as each athlete's skill level advances. Consider that one of the greatest stats a pitcher can have in collegiate and professional baseball is not wins, strikeouts, or ERA, but simply *innings pitched*. From 2001–2010, serious elbow and shoulder injuries were responsible for over *80,000 days* on the MLB disabled list. 80,000 days is over 219 years stolen due to serious arm injuries. Athletes who lose weeks to months of training time for skipping mobility and passive-training modalities due to their "boring" nature have the potential to permanently derail their baseball careers.

As athletes become more advanced and throw harder, recovery becomes significantly more important, even the primary focus for the most elite athletes

(MLB pitchers or serious MLB prospects). It takes much higher training intensities to disrupt homeostasis and generate a neuromuscular response for these athletes, which creates more opportunities for fatigue to set in. Fatigue is a byproduct of increasing the intensity and volume of training—to dissipate and mitigate fatigue, a great deal of attention must be paid to both active and passive modalities that improve recovery time. Not all recovery modalities are exercises: proper nutrition, sleep, rest, study, and passive work all play significant roles in athletes' maintaining healthy and productive bodies for athletic performance.

Autoregulation, the ability to discover limits through training, plays a major role in an athlete's ability to consistently recover from training and competition. Knowing when it's appropriate to limit output and when to throw at 100% rate of perceived exertion (RPE) is an essential skill for athletes to acquire in order to break through barriers and limitations. The primary example of autoregulation application in baseball is Alan Jaeger's long-toss program—not setting time or distance restrictions allows athletes throw according to how they feel as well as in consideration for upcoming training or competition events. This provides a great way for athletes to manage their training economy.

Our training programs list specific sets, reps, RPE percentages, and training schedules that match daily training objectives together in chronological order. These programs are meant to be guides not concrete instructions because athletes must own responsibility in applying autoregulation principles to their everyday training, especially for throwing. The programs we build serve two primary purposes:

1. *Introducing coaches and athletes to multi-factor training while figuring out which training modalities work best*
2. *Provide a basis for athlete test/retest iteration at an individual level*

Structure is a necessary feature of a training program to keep athletes on track towards achieving their performance goals. However, we recognize that not all pitchers are built in the same way, so it would be highly inappropriate to prescribe a one-size-fits-all training program. All athletes have a set of unique traits that influences how they move and apply force to achieve an end objective. This idea brings us to our next chapter: reviewing the anatomy of a baseball pitcher's body.

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ANATOMY 101:
A Brief Overview of the Baseball Pitcher's Body

While an exhaustive anatomical review of the human body is not necessary to effectively understand pitching mechanics well enough to train athletes, there is a base level of knowledge that all coaches and athletes should be able to grasp before embarking on a serious training program. This chapter goes over the basics of the relevant body parts and delves deeper into detail for those who are interested in the nitty-gritty—moving from the feet and ending at the head.

LEGS

Critical for initiating the Stride Phase of the pitching delivery, the legs also provide the primary timing mechanism for initiating the rotation of the hips and eventually the torso. They are also responsible for creating bracing force, ensuring that the pitcher has a stable lead leg to throw against. It is extremely important that the comparatively smaller muscles of the lower leg (gastrocnemius, soleus, tibialis anterior/posterior, calcaneal) are free of adhesions and excessive tightness so both the Stride and Blocking Phases of the pitching delivery can be performed at a high level. The lower leg's primary function in pitching is to stabilize the athlete's lead leg to ensure a rock-solid platform to rotate against.

Striding and rotation are the primary functions of the muscles of the upper legs, particularly the gluteus medius/maximus and rectus femoris. The muscles of the quadriceps also provide serious braking power after landing and "push-off" power for the back leg. Strengthening these muscles through resistance training and plyometric movements can allow them to contract harder, which increases velocity and durability.

CORE

The core of the body is the midsection where the center of mass resides. Everything is driven through it, and studying how the center of mass works is the basis of all biomechanical analysis. While the core of the body is responsible for hip and torso rotation, it is also overlooked as a primary stabilizer of the musculoskeletal system. By strengthening the major muscles of the core—multifidus, obliques, pelvic floor, rectus abdominis, latissimus dorsi, and erector spinae—the athlete is better able to stabilize the spine throughout the pitching delivery, which improves velocity, command, and reduces the chance of fatigue-onset injury.

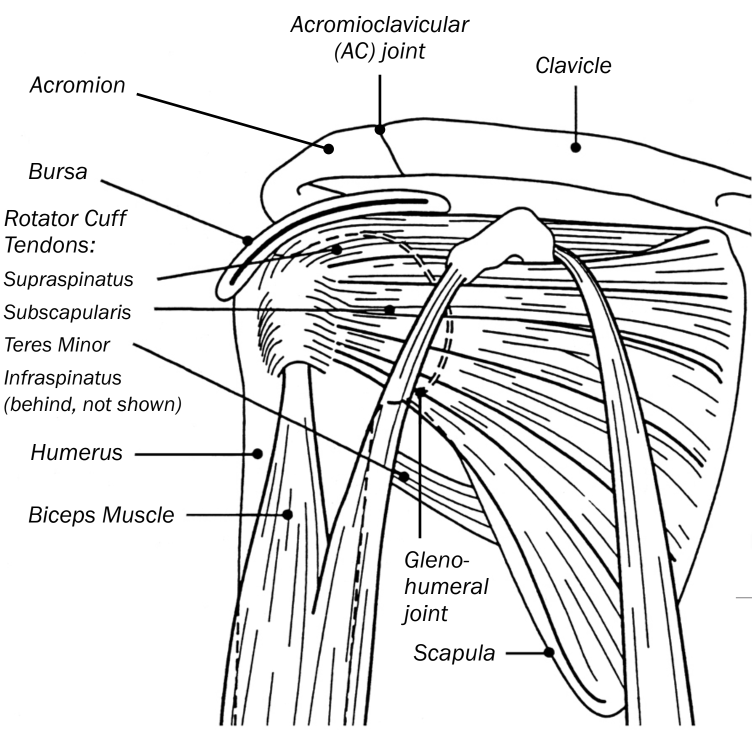
SHOULDER

The shoulders are responsible for some of the fastest movement ever measured in human kinematics—internal rotation during a baseball throw. There are three joints in the shoulder: glenohumeral, acromioclavicular, and sternoclavicular. When discussing the shoulder in general, the glenohumeral joint is usually singled out since it is the ball and socket joint were the proximal humerus rotates inside of the of the glenoid fossa.

There are three primary groups of tissue in the shoulder that deserve focus:

- *Rotator Cuff*
- *Labrum*
- *Major Muscles*

The rotator cuff is a group of muscles and tendons that helps stabilize the shoulder. While the arm is moving, the rotator-cuff muscles are compressing the humeral head and keeping the bone from dis-



A detailed look at the shoulder joint

locating and causing inefficient movement patterns as well as injury. However, the muscles that make up the rotator cuff are not very large.

The muscles of the rotator cuff and their functions are

- **Supraspinatus:** *Abducts the arm (moves arm away from body)*
- **Infraspinatus:** *Externally rotates the arm (Elbow Spiral and Driveline Phases)*
- **Teres Minor:** *Externally rotates the arm (Elbow Spiral and Driveline Phases)*
- **Subscapularis:** *Internally rotates the humerus (throwing the ball)*

The labrum is a rim of tissue around the socket of the shoulder which adds room for the proximal humerus to move while reinforcing it as well. SLAP (superior labrum, anterior to posterior) tears that require surgery are uncommon, but do occur in overhead-throwing athletes.

Major muscles in the shoulder help to stabilize the joint in addition to providing acceleration and deceleration forces throughout the delivery. Serratus anterior is a primary stabilizer of the scapula against the thoracic wall and helps get the arm upwards. Levator scapulae controls the movement of the shoulder blade, allowing for optimal external rotation and tilt into forearm layback. The deltoids, the middle deltoid in particular, are critical to shoulder abduction, but they should not be overly powerful or activated during the pitching delivery. While strong deltoids are desirable to help support shoulder flexion, if they are used significantly in the pitching delivery, they have the potential to overpower the rotator cuff and compress the proximal humerus against the top of the joint, closing the subacromial space. This can lead to shoulder-impingement syndrome or general instability in the glenohumeral joint, so it's important not to overtrain or overactivate the deltoids.

ARMS

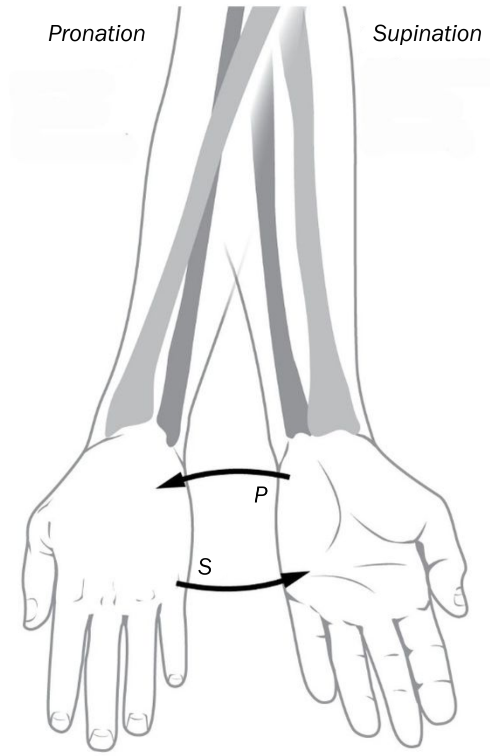
The muscles of the arms are responsible for final transmission of accumulated force throughout the kinetic chain to optimize pitching velocity, but they are equally important when it comes to preventing injury and refining control. The vital muscles of the lower arm—pronator teres, flexor digitorum superficialis (FDS), flexor carpi ulnaris (FCU), pronator quadratus, anconeus—are incredibly important when it comes to maintaining elbow health.

By strengthening the flexor-pronator mass and ensuring proper activation prior to high intensity throwing, the muscles of the lower arm will protect the ulnar collateral ligament (UCL), the connective tissue that is repaired through Tommy John Surgery. These muscles also play a large role in command: if they are fatigued, the pitcher will lose "feel" and have a tough time locating his pitches for strikes.

Planes of Movement

Hacking the Kinetic Chain — Advanced Pitching uses precise wording of human movement, so here are a few diagrams that cover the basic movements of the arm:

palm down = pronation,
palm up = supination



Internal Rotation vs.
External Rotaiton